SHORT ANSWERS AND OBJECTIVE TYPE QUESTIONS IN

PHYSICS

B.L. Sharma

ARYA BOOK DEPOT
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SHORT ANSWERS
AND
OBJECTIVE TYPE QUETIONS
IN
PHYSICS

Designed to meet the changing trends in the examinations, vide Circular No. 25237–26083/C, dated 6-10-72 sent to all the Heads of Affiliated Institutions and the latest revised and elaborated instructions for the guidance of Paper-Setters for the examination of 1976 and onwards.

SHORT ANSWERS AND OBJECTIVE TYPE QUESTIONS

C

IN

PHYSICS

[Complete with concise physics, objective type questions and short-answer questions branchwise and their answers]

For

All-India Higher Secondary, Delhi Higher Secondary,
Multi-purpose Higher Secondary, Technical Higher Secondary,
I.S.C., Prep., Pre-Engineering, Intermediate,
P.M.T., T.D.C. 1st year,
and National Science Talent Search Examinations, etc.

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PREFACE TO THE SECOND EDITION

The fine reception given to "*Short Answers And Objective Type Questions In Physics*" in past years has been most encouraging. To enhance the readability and helpfulness of this revised edition, not only many stimulating questions have been added but also every sentence of the previous edition has been read and pondered over in the light of following questions :

(*i*) Is this still true ?

(*ii*) Is it still important ?

(*iii*) Can this be said more clearly ?

Consequently some explanatory material has been either shifted to footnotes or written within brackets so that the answers become more precise and to the point.

The author will feel amply rewarded if the students, after reading this book, begin to take a genuine interest in the subject and develop the skill of applying basic principles of Physics to new and challenging situations.

November, 1975 B.L. SHARMA

PREFACE TO THE FIRST EDITION

The trends of public as well as competitive examinations are rapidly changing. In the First Paper-Setters' Workshop held at Kanpur in October 1968, the Central Board of Secondary Education, New Delhi decided that instead of depending upon essay type and routine stereo-type questions, stress should be laid on setting more and more objective, matching, multiple-choice and short-answer type questions to achieve an effective and better-coverage of the entire syllabus. To avoid sudden departure from tradition, the Board permitted this intervening transitional period of four years in some subjects. But with effect from the examination of 1973, in every question paper the objective type and short answer type questions will carry a minimum weightage of 50% to bring the characteristics of validity, reliability, objectivity and usability in a Question Paper in order to test knowledge, understanding, applications, skills and attitudes of the candidates. This is clear from the Extacts (given below) from the REVISED AND ELABORATED INSTRUCTIONS FOR THE GUIDANCE OF PAPER-SETTERS for the All-India Higher Secondary, Delhi Higher Secondary, One-Year Higher Secondary, Multi-purpose Higher Secondary, Technical Higher Secondary and Chandigarh Higher Secondary Parts I and II Examinations of 1973 sent by the Secretary, Central Board of Secondary Education, New Delhi to all the Heads of Affiliated Institutions vide Letter No. 25237–26083/C, dated 6th October, 1972 :

1. The question-paper should cover, as far as possible, the whole range of topics mentioned in the syllabus. The coverage should not only be comprehensive but also well balanced by spreading the questions on all significant topics and sub-topics prescribed for study.
2. About half of the questions should be set to test higher abilities, such as understanding/comprehension, application of knowledge and development of skills. For this purpose, the questions should be set in the context of a new situation rather than to give a routine stereo-typed answer.
3. Each question should be set on specific aspects of a topic rather than making it a general question which admits a large variation in the content of expected answer. As far as possible, the maximum length of the expected answer should be prescribed.
4. **Essay-Type Questions** : Special efforts should be made to make each essay-type question more specific and pointed in scope by avoiding ambiguous directions and by splitting the question into small units and alloting specific marks for the sub-units.
5. **Short-Answer Questions** : For adequate coverage of the entire syllabus, a large number of short-answer questions are to be set. This will improve the reliability of the examination by reducing the subjectivity of marking inherent in essay-type questions.

   The range of response to short-answer questions may vary from one or two lines to a paragraph or two. The expected length of the answer should be indicated in each question.
   About half (*i.e.* 50%) of the maximum marks available for a question-paper should be allotted to short-answer questions.
6. **Objective-Type Questions** : Unless otherwise mentioned in the syllabus, there should be at least one question of the objective type in each question-paper. The relevant question (s) should be made compulsory for all the candidates.
   Marks allotted to such question(s) should by 10—15% of the total marks allotted to the question-paper.
   The objective-type question (s) should not be confined to only one topic but should cover as wide a syllabus as possible. No part of such a question should carry more than one mark.
   The formation of the objective-type question(s) could be of the Recall, Selection, Multiple Choice, Matching, Completion, etc. type but *not* "YES and NO" type.
7. **No General Choice** : No unqualified choice like "Do any five questions" or "Do any two questions from part I" etc. is to be provided to the candidates.
   The choice, if any, should be restricted to the internal options against the questions on the same major topic or sub-topic of the syllabus.

January, 1973.

B.L. SHARMA

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Concise Mechanics

1. The study of **Physics** deals with two things only—matter and energy and their interaction, keeping always in view the time and space.

2. Whatever can be judged and detected with the help of one or more of our five senses is termed as **matter.** *Matter is the vehicle of energy.* Energy cannot exist except in connection with matter.

The force of attraction that binds the molecules of the same substance or kind is called the **force of cohesion** while the force of attraction that binds the molecules of different kinds or substances is called the **force of adhesion.**

3. **Unit** is a definite and convenient measure with the help of which we can measure various quantities of similar type.

Every unit should be such that it can be easily reproduced and is adopted by all in their dealings.

4. **C.G.S.** (or French or Metric or Decimal) and **F.P.S.** (or British) **Systems** are two, more prevalent systems of units commonly employed in scientific measurements.

C.G.S. system is more convenient than F.P.S. system.

For engineering purposes, units under **M.K.S.** or **S.I.** (International System) are employed.

5. **Fundamental Units** : These are the units of length, mass and time which are independent of one another and form the basis of units of all other quantities.

There are **only five absolute fundamental units** which are cm., foot, gm., lb. and second. All other multiples and sub-multiples of these five units are called **practical fundamental units.**

6. **Derived Units** : All other units, except those of length, mass and time*, are called derived units since they can be expressed in terms of the fundamental units. Dimensions of some physical quantities (temperature, electricity, etc.) cannot be given in terms of mass, length and time alone.

Absolute derived units are those which are derived with the help of absolute fundamental units.

Similarly, **practical** derived units are those which are derived with the help of practical fundamental units.

---

*A unit of time equal to one million years is called a **cron.**

7. The shortest distance which can be correctly measured by a vernier callipers is called its **least count** or **vernier constant** (=1 S.D.−1 V.D. generally).

The linear distance through which a screw moves in one complete revolution of the screw head of an instrument is called its **pitch** while the linear distance through which the screw moves when the screw head is rotated through one division of head scale is termed as the **least count** of the screw.

8. **Zero-error** of an instrument can be *positive* or *negative*, and is always to be subtracted from the quantity under measurement.

If we change the sign of zero-error, the quantity so obtained is called **zero-correction** which is always to be added to the observed reading.

9. **Vector** quantities are those which need magnitude and direction, both, to specify them completely (*e.g.* velocity, acceleration, force, momentum and magnetic or electric field strength).

Scalar quantities possess magnitude only and have no direction associated with them (*e.g.* speed, mass, money and temperature).

10. A vector can be represented in magnitude and direction by a st. line (drawn on a certain scale) bearing an arrowhead. One end of this line represents the point at which this vector is applied.

11. The **velocity** of a body is its speed in a given direction. Therefore, if the direction of motion changes but the speed remains the same, the velocity has changed.

A body is said to move with **uniform velocity** when it travels equal distances in the same direction in successive equal intervals of time, however small.

12. A body is said to be **accelerating** when its velocity is increasing and **decelerating** or **retarding** when its velocity is decreasing.

Acceleration (+ve or −ve) is equal to the rate of change in velocity of a body.

A body is said to be **uniformly accelerated** when its velocity changes by the same amount in successive equal intervals of time, however small.

13. **Equations of Uniformly Accelerated Motion** : Let u be the initial velocity of a body which possesses a uniform acceleration a so that after a time t the body covers a distance s and acquires a final velocity v. Then

$$v=u+a.t\,; \qquad 2a.s=v^2-u^2$$

$$s=\left(\frac{v+u}{2}\right)\times t \;=u.t+\tfrac{1}{2}a.t^2$$

And the distance covered by the body in any one particular second (say nth) is given by

$$s_{nth}=u+\frac{a}{2}(2.n-1)$$

14. Graphical Representation :

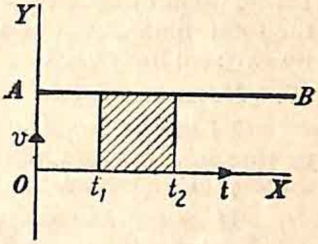

Fig. 1-1

(*a*) Velocity-Time graph *AB* for uniform velocity motion (Fig. 1-1).

(*b*) Velocity-Time graph *AB* for uniformly accelerated motion

(*i*) with initial velocity=zero (Fig. 1-2) ;

(*ii*) with initial velocity=u (Fig. 1-3).

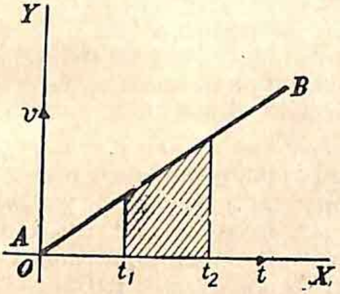

Fig. 1-2

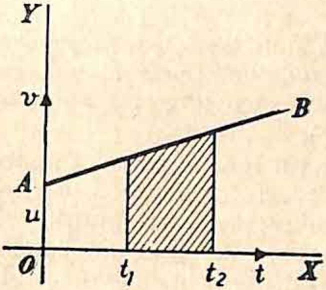

Fig. 1-3

(*c*) Distance-Time graph *AB* for uniform velocity motion (Fig. 1-4).

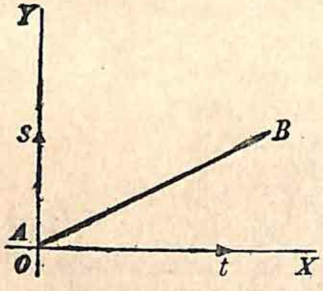

Fig. 1-4

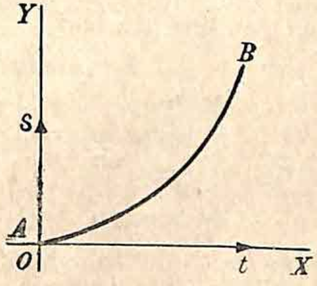

Fig. 1-5

(*d*) Distance-Time graph *AB* for uniformly accelerated motion (Fig. 1-5).

In Figs. 1-1, 1-2 and 1-3, the distance travelled between times t_4 and t_2 can also be represented by the shaded area shown.

The **slope** of the line for Velocity-Time graph gives the acceleration of the body in motion.

15. The **momentum** of a body is the product of its mass and velocity.

C.G.S. absolute unit of momentum is *dyne*×*second* and F.P.S. absolute unit is *poundal*×*second.*

16. The **principle of conservation of momentum** states that the total momentum of a system of bodies remains constant, provided no external forces act.

17. Newton's Laws of Motion :

I Law—Every body continues in its state of rest or of uniform motion **in a st. line** unless it is compelled by some external impressed force to change that state. [It is also called the **Law of Inertia**].

II Law—The rate of change of momentum of a body is proportional to the impressed force and takes place **in the direction** in which the force acts.

III Law—To every action, there is an equal and opposite reaction.

It should be noted, however, that Newton's laws do not apply to particles moving at very high speeds because then mass, length and time start changing in accordance with Einstein's Theory of Relativity.

18. Inertia is a property of matter and is independent of where the matter is. Hence, in a space-craft, the passengers may be weightless whilst orbiting the earth but they are not massless and hence they have inertia. A spaceman cannot drop a hammer on his foot but if he throws it, the damage done will be the same as on earth.

19. Measurement of Force and its Units :

Mechanics is that branch of Physics which deals with the action of force or forces on matter while a **force** is a push or pull which changes or tends to change the state of rest or of uniform motion in a st. line of a body.

Force=Mass×Acceleration

1 **dyne** $=(1\text{ gm.})\times(1\text{ cm./sec}^2)$
1 **poundal** $=(1\text{ lb.})\times(1\text{ ft./sec}^2)$
1 **gm. wt.** $=g$ dynes$=981$ dynes
1 **lb. wt.** $=g$ poundals$=32$ poundals
1 **newton** $=(1\text{ kg.})\times(1\text{ metre/sec}^2)=10^5$ dynes.

20, Mass (m) is the amount of matter constituting a body while its **weight** ($W=m.g$) is the force of gravity with which a body is attracted by earth towards its centre.

Mass is a scalar quantity while weight is a vector quantity.

Mass of a body always remains constant everywhere and is an essential property of matter. But the weight of a body changes from place to place as the value of g changes. The weight of a body becomes zero at the centre of the earth or at a place far away from earth. Hence *weight is not an essential property of matter.*

Metric slug is the mass which is accelerated by 1 metre/sec² by a force of 1 kg. wt. It is equal to g kg. wt.$=9{\cdot}8$ kg. wt. It is sometimes called a **mug**, a **par** or a **T.M.E.** (Engineering Mass Unit abbreviated in German).

21. Parallelogram Law of Vectors (say Velocities or Forces) : If a particle (say K, Fig. 1-6) possesses simultaneously *two* uniform velocities (say u and v) (or is acted upon simultaneously by two forces), represented in magnitude and direction by the two adjacent sides (OA and OB) of a parallelogram ($OACB$) drawn from a point (O, Fig. 1-7), their resultant (R) is completely represented both in magnitude and direction, by the diagonal (OC) of the parallelogram passing through the same point (O).

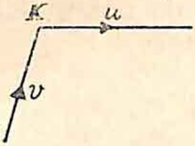

Fig. 1-6

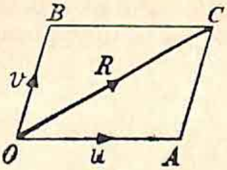

Fig. 1-7

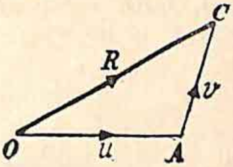

Fig. 1-8

22. Triangle Law of Velocities (or Forces or any other Vectors) : If a particle (say K, Fig. 1-6) possesses simultaneously **two** uniform velocities (say u and v) (or is acted upon simultaneously by two forces), represented in magnitude and direction by the two sides (say OA and AC) of a triangle **taken in order** (Fig. 1-8), their resultant is completely represented, both in magnitude and direction, by the third side taken in opposite order (*i.e.* OC).

23. Triangle of Velocities (or Force or other Vectors). If **three coplanar** velocities (or forces) acting on a parlicle K (Fig. 1-9) be represented in magnitude and direction by the sides OA, AC, CO (Fig. 1-10) of a triangle, *taken in order*, their resultant will be zero.

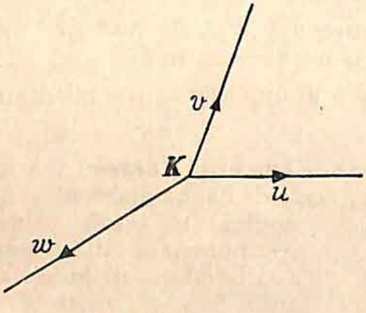

Fig. 1-9

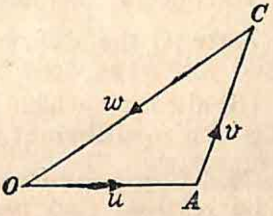

Fig. 1-10

Its converse is also true *i.e.* if a particle under the action of three coplanar velocities (or forces) be in the position of equilibrium, then these velocities (or forces) can be represented by the sides of a triangle, taken in order.

24. Polygon Law of Velocities (or Forces or any other Vectors) : If a particle (say O, Fig. 1-11) possesses simultaneously more than two uniform velocities, u, v, w, etc. (or is acted upon simultaneously by more than two constant forces), represented in magnitude and direction by the sides (*AB*, *BC*, *CD*, etc.) of a polygon, **taken in order** (Fig. 1-12), their resultant *R* is completely represented, both in magnitude and direction, by the closing side (*AF* and not *FA*) of the polygon, taken in opposite order.

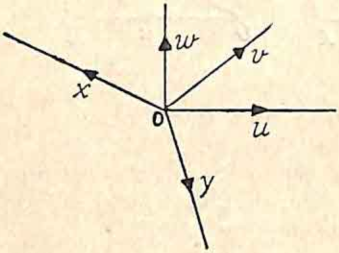

Fig. 1-11

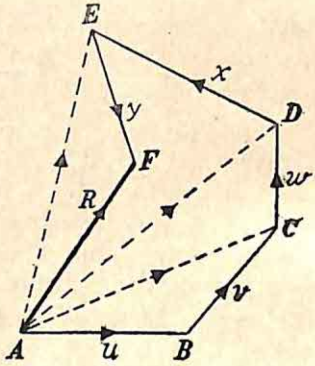

Fig. 2-12

25. Polygon of Velocities (or Forces or any other Vectors) : If any number of coplanar velocities (or forces) acting at a point be such that they can be represented both in magnitude and direction by the sides of a **closed** polygon, **taken in order,** their resultant will be zero.

Its converse may not be always true.

Note (i) the difference between §22 and, and §23, between §24 and §25. The word "Law" is not present in §23 and §25 ;

(ii) the force which is equal and opposite to the resultant force is called the **equilibriant force.**

26. Components of a forces (or any Vector) : A force (*F*) can be resolved into two parts, called its components, at right angles to each other. One component of this force along a direction making a given angle (say θ°) with *F* will be *F*. cos θ while the other will be *F*. sin θ (Fig. 1-13).

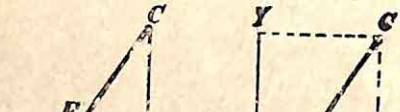

Fig. 1-13

27. Multiplication of Physical Quantities : When one physical quantity is multiplied by another, the product is a quantity different in nature from the factors. The product *force* × *distance* is termed *work* or *moment*. Sometimes the product is a quantity less familiar to us. We do not know the nature of the product *length* × *volume* ; but this does not prevent us from working on such quantities.

28. Relation between g and G : Here g is the acceleration of a body falling towards the centre of the earth on account of the force of gravity and G is the **Gravitational Constant** ($=6{\cdot}67\times10^{-8}$ *C.G.S.* units). If M be the mass of earth and R its mean radius, then

$$g=G\ \frac{M}{R^2}$$

(*i*) *On the surface of earth,* $g\propto\frac{1}{R^2}$

(*ii*) *Away from earth at a height h,* $g\propto\frac{1}{(R+h)^2}$

(*iii*) *Inside* earth at a depth h,* $g\propto(R-h)$

(*iv*) *At the centre of earth,* $g=0$

Note : Light rays also bend under the gravitational fields of stars, more so under stronger fields. The effect is very similar to the moving of a horizontally fired bullet along a parabola under the influence of gravity. Thus, *light possesses the property of inertia and therefore of mass.*

29. For a Simple Pendulum, if l be its effective length, then its time period $t=2\pi\sqrt{l/g}$

(*i*) On increasing length (due to rise of temp.) and/or decreasing g, since t will increase, therefore a clock will run slower.

(*ii*) On decreasing length (due to fall of temp.) and/or increasing g, since t will decrease, therefore a clock will run faster.

Note : Value of g can also decrease on account of rotation of the earth as the weight of a body will be opposed by the centifugal force ($=mv^2/r$).

30. Work : Work means accomplishment, not mere fatigue. Work done by or against a force is given by the product of the force and the distance its point of application moves **in the direction of the force** or against it.

$\because$ Work = (Force) × (Distance along force)

$\therefore$ 1 erg = 1 dyne × 1 cm. along force

1 ft. poundal = 1 poundal × 1 ft. along force

1 joule = 1 newton × 1 metre along force

(1 joule $=10^7$ ergs ; 1 gm. cm. $=g$ ergs ; 1 ft. lb. $=g$ ft. poundals).

31. Power : It is the rate of doing work.

Its absolute units are erg/sec. and ft. poundal/sec.

Its practieal units are (*i*) 1 joule/sec. = 1 **watt** and (*ii*) 550 ft. lb./sec. = 1 **H.P.**

In C.G.S. system, its engineering unit is **kilowatt** (= 1000 watts).

---

* But in the actual practice, g at first increases with the depth because the central portions of the earth are much denser than the crust.

Kilo-watt×Hour or *K.W.H.* is the engineering unit of work or energy in *M.K.S.* system and its value$=1000\times3600$ joules.

32. **Work and Energy** : These indicate the same physical quantity and therefore have the same units. 'Energy' is used in all branches of Physics, but work is usually reserved for mechanical cases of energy.

Energy is the capacity of a body for doing work.

33. **Potential Energy** of a body is due to its position and for a body of mass m at a height h, its value$=m.g.h.$

Kinetic Energy of a body is due to its motion and for a body of mass m moving with a velocity v, its value$=\frac{1}{2}mv^2$.

34. **Principle of Conservation of Energy** : Man is unable to create or destory energy ; he can only transform it from one kind to another. Thus the sum total of energy always remains same.

35. **Laws of Static Friction** : Friction is defined as the resistance offered to the movement of one body upon another or through another. No friction comes into play if the body has no tendency to move, *i.e.* the friction has no independent existence of its own. Its laws are :

(1) The frictional force always opposes motion.

(2) The frictional force is self-adjustable but has an upper limit called the limiting friction (F) whose magnitude is just sufficient to oppose motion.

(3) The ratio of limiting friction (F) to the normal reaction (R) (between the surfaces) is called the coefficient of friction (between the two given surfaces) ;

i.e. $\mu=F/R$

(4) The limiting friction, for a given normal reaction, is dependent upon the *nature* of two surfaces in contact and *not on their extent* (*i.e.* area).

When the coefficient of friction of a surface is equal to zero, the surface is said to be perfectly smooth. No such surface exists in practice and we do not wish to have such a surface. Actually, friction is a necessary evil. Friction between the cup and the tea slows down the stirred tea near the edge.

36. **Angle of Friction** : (*i*) It is the angle between the normal reaction and the resultant of limiting friction and normal reaction.

(*ii*) When the angle of inclination of a plane is gradually increased till the body kept on it *just starts sliding down*, then the angle (say θ) which the plane now makes with the horizontal is called the angle of friction.

[On the other hand, the angle which the plane makes with the horizontal when the body kept on it *just stops sliding down* is called the **angle of repose**].

Note that $\mu = \tan\theta$

37. Moment of a Force is its turning effect. It is measured by the product of the force and the *perpendicular distance* (called *arm* of the force) from the pivot to the line of action of the force.

Moment is a **vector** quantity. Anticlockwise moment is taken as positive and clockwise moment as negative.

Magnitude of moment can also be represented by twice the area of the triangle whose base is the given force and altitude is the arm of the force.

38. Principle of Moments states that in any system in equilibrium the sum of the moments in clockwise direction about any point is equal to the sum of the moments in anticlockwise direction about the same point (**or** the *algebraic* sum of the moments about any point in the same plane is equal to zero).

39. Resultant of Parallel Forces :

(*a*) Resultant of **two like parallel forces** is equal to their sum, acts parallel to each of them and acts at such a point which divides the distance between the two forces *internally* in their inverse ratio.

From Fig. 1-14, $F \times AC = Q \times BC$

or $$\frac{P}{Q} = \frac{BC}{AC}$$

That is, the resultant will be near the greater force and away from the smaller force.

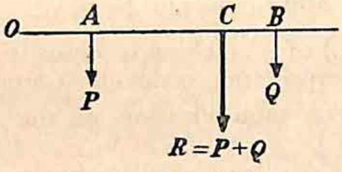

Fig. 1-14

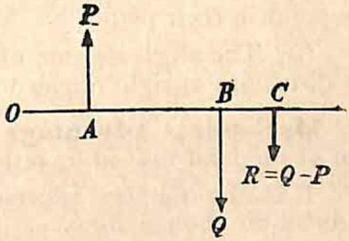

Fig. 1-15

(**b**) Resultant of **two unlike parallel forces** is equal to their difference, acts in the direction of the greater force and acts at such a point which divides the distance between the two forces *externally* in their inverse ratio.

From Fig. 1-15, $P \times AC = Q \times BC$

or $$\frac{P}{Q} = \frac{BC}{AC}$$

That is, here too the resultant will be near the greater force and away from the smaller force.

40. Couple : Two equal, unlike and parallel forces having different lines of action constitute a couple.

The **moment of a couple** about any axis of rotation is equal to the product of either force and the arm (=prependicular distance between two forces) of the couple.

The function of a couple is to produce rotation in the body.

A couple can be balanced by an equal and opposite couple and never by a single force.

41. Centre of Gravity (C.G.) of a body is the point, *in or outside the body*, at which its weight may be considered to act vertically downwards. It may also be termed the **centre of mass.**

42. Equilibrium : A body is said to be in the position of equilibrium when under the influence of two or more forces the body maintains its original position of rest or of uniform motion along a st. line. In other words, *zero acceleration* has heen given another name as equilibrium.

A body is said to be in **stable equilibrium** if on suffering a *slight* displacement its C.G. is raised. The body returns to its original position when the disturbing force is removed.

If C.G. is lowered by the displacement, then the equilibrium is **unstable** and the body falls away from its original position.

If C.G. is neither raised nor lowered by the displacement, then the equilibrium is said to be **neutral** and the body even in its new position remains in its original position.

43. Conditions of Equilibrium of Coplanar Forces :

(*i*) The algebraic sum of moments of forces must be zero about any point in their plane.

(*ii*) The algebraic sum of the resolved parts of the forces in any two directions at right angles to each other must also be zero.

44. Mechanical Advantage (M.A.) of a machine is equal to the ratio of the load moved or resistance overcome to the effort applied.

It is the *number* expressing the multiplication of the force produced by the machine.

Velocity Ratio : It is equal to the ratio of the velocity of the effort applied to that of the load moved.

It is also equal to the ratio of the distance through which the effort works to the distance through which the load is moved.

Efficiency of a machine is equal to the ratio of the work done by the machine (called *output*) to the work given to the machine (called *input*).

It is also defined as a *fraction of input converted into useful work.*

M.A. = (Efficiency) × (Velocity Ratio)

Being the ratio of two similar quantities, any one of these three quantities is a *pure number* having no units.

45. **Efficiency of a man** working under good conditions is about 25%. But there are very great differences between the ordinary machine and the human machine : (*i*) Man has a brain and can think and can control the expenditure of his energy while everything that the machine does is controlled from outside ; (*ii*) When man damages his body, to a large extent he can carry out the repairs himself while when a machine is damaged, the effected part has to be replaced : (*iii*) Like all living creatures, man is able to reproduce his kind ; this a machine cannot do ; (*iv*) Finally all machines are made by man.

46. **Lever** is a rigid bar, straight or bent, capable of rotatory motion about a fixed point called *fulcrum*.

$$(\text{Effort}) \times (\text{Effort Arm}) = (\text{Load}) \times (\text{Load Arm})$$

or

$$\text{M.A.} = \frac{\text{Load}}{\text{Effort}} = \frac{\text{Effort Arm}}{\text{Load Arm}}$$

Types* of Levers : [**F, W, P**; of levers three,
Must each, in turn, the centre be.]

47. **M.A. of Wheel and Axle** $= \dfrac{\text{radius of wheel}}{\text{radius of axle}}$

A ship's capstan, an old-fashioned mangle, the modern wringer, a mincer, a coffee mill and the starting handle of a car, etc., etc., are some applications or examples of a wheel and axle.

48. **Inclined Plane** (its angle is $\theta°$) : *e.g.* a stair case, a slopy path.

(*i*) When effort acts parallel to the plane : M.A. $=\operatorname{cosec}\theta$

(*ii*) When effort acts in horizontal direction : M.A. $=\cot\theta$

49. **Wedge** (its angle is $\theta°$) : M.A. $= \dfrac{1}{2\sin(\theta/2)}$

Axe, hatchet, chisel, knife, blade, plough, etc. are some examples of a wedge. Nail, needle and pin are examples of pointed wedges.

50. **Screw** *or* **Screw Jack** (Fig. 1-16) : If R be the radius of the handle and h its pitch, then

$$\text{M.A.} = 2\pi R/h$$

51. **Single fixed pulley** (Fig. 1-17) has a M.A. $=1$.

Single movable pully (Fig. 1-18) has a M.A. $=2$.

52. **In the first system** of pulleys (Fig. 1-19), each string is fastened to the supporting beam and if n be the number of pulleys,

$$\text{M.A.} = 2^n$$

In the second system of pulleys (Fig. 1-20), the same string passes round all the pulleys which are arranged into sheaves. If n be the number of pulleys in the lower sheaf,

$$\text{M.A.} = 2.n = \text{no.of strings at the lower sheaf}$$

---

*What type of the lever acts when you (*i*) nod your head forwards or is pulled upright again or (*ii*) raise yourself onto your toes ?

In the third system of pulleys (Fig. 1·21), all the strings are attached to the load. If n be the number of pulleys,

$$\text{M.A.}=2^n-1$$

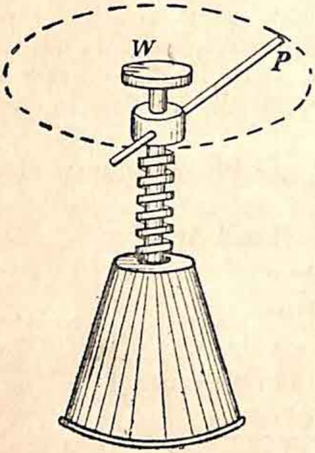

Fig. 1-16

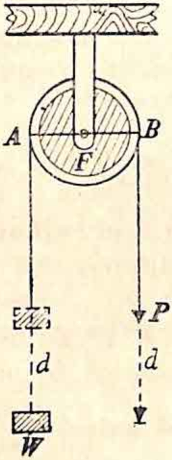

Fig. 1-17

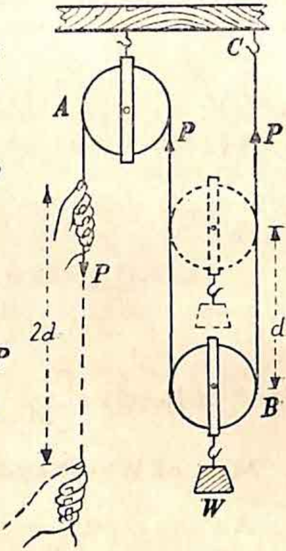

Fig. 1-18

In a differential pulley (Fig. 1·22), $\text{M.A.}=\dfrac{2R}{R-r}$

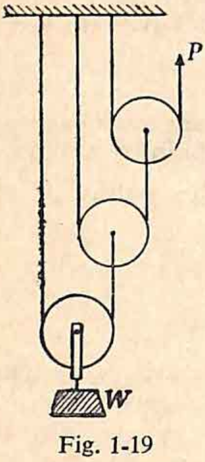

Fig. 1-19

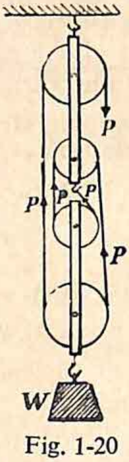

Fig. 1-20

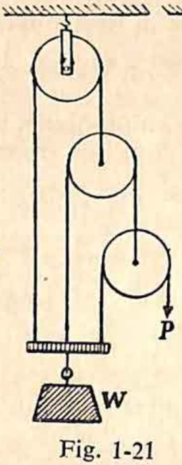

Fig. 1-21

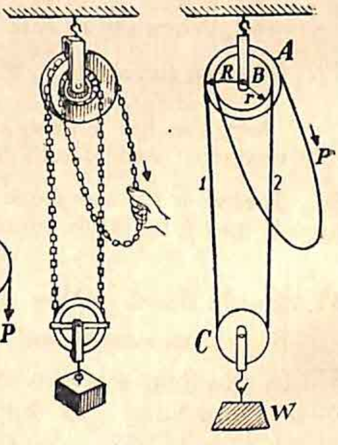

Fig. 1-22

Note : For all the machines mentioned above, we have calculated V.R. which is equal to M.A. when efficiency is one.

53. Gears are merely toothed (or cogged) wheels such that the tooth (or cog) of one exactly fits into the spacing of the other. As one of the gears is rotated, the motion is transmitted to the other through these interlocking teeth. Thus gears offer one of the methods to transmit power from the driving machine to the driven machine.

Gears have the advantage of maintaining exact velocity ratio between the driving and the driven shafts which is not possible with the use of belts as they are subject to slippage. For any gear combination :

$$\frac{\text{No. of revolutions of wheel } A}{\text{No. of revolutions of wheel } B}=\frac{\text{No. of teeth } n_2 \text{ on } B}{\text{No. of teeth } n_1 \text{ on } A}$$

Thus by adjusting n_1 and n_2, the rate of rotation (*i.e.* the speed) of the driven wheel can be increased or decreased.

54. **Balance** : Generally we use our right hand. In the right hand pan of a balance we should put that article (weights or object being weighed) whose quantity we have to change for bringing the beam to the horizontal position. A shopkeeper has to change the quantity of the object being sold while in the laboratory we have to change the weights. That is why a shopkeeper puts weights in L.H. pan and the students in the laboratory have to put weights in R.H. pan. Reverse will be applicable for a left-hander.

A balance is said to be **true** if its beam remains horizontal for no weights or equal weights placed in its pans. For this, its arms should be of equal lengths and its pans of equal weights.

A balance is said to be **sensitive** if a small difference in the weights kept in its pans causes an appreciable deviation of the beam from its horizontal position. To achieve this goal, the distance (say h) between the fulcrum of the beam and C.G. of the balance should be minimum.

A balance is said to be **stable** if its beam returns to its original horizontal position quickly, when disturbted, for no weights or equal weights kept in the two pans. For this purpose, h should be maximum, which shows that stability is opposed to sensitiveness.

A balance is said to be **rigid** when it does not suffer any change in shape (*e.g.* by bending of the beam, etc.). This requires a fairly strong and massive beam.

55. **Elasticity** is that property of matter by virtue of which a body offers resistance to the external (or deforming) forces and regains its original shape and dimensions when the deforming forces are removed.

Stress is an equal and opposite reaction from within the body resisting deformation and tending to restore the body to its original shape and dimensions. It is measured by the force applied per unit area of the body. The unit of stress in M.K.S. system is called a **pascal** which is equal to a force of one newton per square metre.

Strain is the change per unit dimensions or shape produced by the stress. It is a *pure number* having no units.

Modulus of Elasticity is the ratio of the stress applied on a body and the corresponding strain produced in it, provided that the applied stress is within the elastic limit of the body.

Modulus of elasticity is also equal to that stress which produces a unit strain in the body. Hence its units are dyne/cm², newton/m² and kg/m².

Strains are proportional to the stresses producing them, provided that the applied stress is not large. It is known as **Hooke's Law.**

Young's Modulus of a solid is equal to that tensile stress which will produce a unit tensile strain in a body, *i.e.* which will double the length of a body.

Even within the elastic limit, bodies do require some time to regain their original shape and size after the deforming force has been removed. This behaviour is known as **elastic fatigue** or **elastic after-effect.**

If the deforming force exceeds the elastic limit, the body is permanently strained and does not regain its original condition. This is called **permanent set.**

If the stretching force is gradually increased beyond the elastic limit, the strain is not proportional to stress. A point is reached where the wire appears to flow. This is called **yield point.**

The breaking stress for a wire of unit cross-section is called its **tensile strength.**

56. **Isothermal elasticity** of a gas is equal to its pressure ($E_i = P$).

Adiabatic elasicity of a gas is γ times its pressure ($E_a = \gamma.P$) where γ is the ratio of the sp. heats of a gas at constant pressure and at constant volume.

57. **Surface Tension** : The behaviour of liquids to exhibit a free surface is caused by certain forces, acting along the liquid surface that tend to shrink the surface to the smallest possible size and thus the liquid behaves as though its surface was covered with a sort of elastic membrane that has a tendency to shrink constantly in size. This force is called the surface tension which is measured in **dynes/cm** or **poundals/ft.** or **newtons/metre.**

Liquids which wet the surface of glass will rise up in a glass capillary tube while others which do not wet the surface of glass will fall down in a glass capillary tube.

We cannot make a *sand pie* with dry sand. The pie collapses as soon as the bucket is taken away. But if we use wet sand, the surface tension of the water holds the grains of sand together.

Surface tension of every liquid decreases as the temp. rises. At the critical point, the surface tension vanishes so that there is no definite line of separation between a gas and a liquid.

All sorts of impurities, contaminations and dissolved substances decrease the surface tension of a liquid. Surface tension also decreases when an electric current is passed through the liquid.

Surface tension depends on the nature of the medium in contact with the liquid, *e.g.* surface tension of free mercury is different from its surface tension when in contact with a liquid.

58. **Viscosity** : It is an inherent property of all fluids, by virtue of which retarding forces are called into play within a fluid when any relative motion between its layers (which generally never flow with the same velocity) occurs. Normal circulation of blood is hampered by viscosity ; to overcome it, the heart must be a powerful pump.

Viscosity is independent of the density as well as the pressure of a gas provided that the pressure is not extremely low.

In a **streamline motion**, the velocity of flow is not large so that the various layers continue to move along parallel paths. If the velocity of flow is large, the various layers cannot remain parallel so that these layers moving along zig-zig paths create whirl pools. Such a motion is known as the **turbulent motion.**

59. **Bernoulli's Principle** : The sum total energy (=kinetic energy + potential energy + pressure energy) is not changed during the displacement of a fluid. Since K.E., P.E. and Pr. E. are mutually convertible, so a loss in one will give rise to the gain in others. Assuming that at a given height, P.E. remains constant, then in the region where the velocity of a fluid is smaller, the pressure is higher and *vice-versa.*

60. **Pressure** exerted by a fluid (liquid or gas) is the force (or thrust) acting on a unit area and acts equally and normally in all directions.

$$P = (\text{height of fluid}) \times (\text{its density}) \times g$$

$$= h.d.g \text{ dynes/cm}^2 \text{ or pdls/ft.}^2 \text{ or newtons/m}^2$$

Pressure is equally transmitted in all directions through a fluid (**Pascal's Law**). Bramah Press works on this law.

At all points at the same depth beneath a liquid surface at rest, the pressure is same from all directions and is proportional to the depth.

61. **A.P.** : The wholly or partly immersed body will experience an apparent loss of weight equal to the weight of liquid displaced by its immersed part.

Gases also obey A.P.

A body which floats, displaces a weight of liquid equal to its own weight (**Principle of Floatation**).

62. **Atmospheric Pressure** : It is the pressure (=weight per unit area) due to the weight of the atmosphere (which is an envelope of air all around the earth extending upto a height of 500 km. or so) at the earth's surface. It is not a constant but varies with time.

Standard or Normal atmospheric pressure is that which will support a column of mercury 76 cm. high at $0°C$ at sea-level. This pressure is called **one atmosphere.**

A pressure of 10^6 dynes/cm^2 is called a **bar.**

Some astronomers believe that millions of years ago the earth had an atmosphere having large quantity of hydrogen, most of which has been lost to space. The reason is that the molecules of hydrogen travel with a velocity nearly four times that of oxygen or nitrogen, hence they diffuse out quicker than other gases of the air. Moreover, pull of gravity is also minimum on hydrogen being the lightest gas and its particles shoot upwards into space.

63. **Barometers** are the instruments which measure atmospheric pressure. Literally, a barometer means "*weight-measure*" which reminds us that it is an instrument for measuring the weight of the air.

No liquid is used in an **aneroid** barometer.

64. **Boyle's Law** : Temperature remaining constant, the volume of a given mass of an enclosed dry gas varies inversely as the pressure to which it is subjected.

$$V \propto \frac{1}{P} \quad \text{or} \quad P \propto \frac{1}{V} \quad \text{or} \quad P.V = \text{constant}$$

At all temperatures and pressures, Boyle's Law is applicable only to a **perfect** or **ideal** or **imaginary gas** whose particles neither possess any weight nor occupy any space.

For real gases, Van der Waal's Equation holds good under all circumstances while Boyle's Law applies at temps. remote from their temps. of liquefaction.

65. In an **air or exhaust pump**, both the valves open outwards. Perfect vaeuum cannot be created with such a pump.

In a *vacuum pump*, there is either no valve on the mouth of the tube connecting the pump to the vessel to be exhausted (*e.g.* Diffusion pump, Filter pump, Rotary oil pump) or this valve does not operate with the pressure of the gas in the vessel to be exhausted (*e.g.* Toepler's pump).

66. **In a compression pump**, both the valves open inwards.

67. **Siphon** : It is a piece of apparatus that can be used for transferring liquid from one vessel (called the container) to another (called the receiver). It is useful in the following circumstances :

(*i*) When the container is at a higher level than the receiver.

(*ii*) When the container is too heavy to be lifted (*e.g.* a barrel).

(*iii*) When the liquid in the container has a sediment that must not be disturbed (*e.g.* a fish tank).

(*iv*) When the container is fixed to a base (*e.g.* a boiler, motor car petrol tank).

Objective Type Questions

CHAPTER I

UNITS, THEIR SYSTEMS AND MEASUREMENTS

I. Complete the following statements with correct word or words :

(1) Fundamental units are the units of......

(2) In all, there are......absolute fundamental units.

(3) ......are the only absolute fundamental units.

(4) The linear distance moved by a screw when its head completes one revolution is called the......of the screw.

(5) The distance moved by the screw when it is rotated through one division of the circular head scale is known as the........of the screw.

(6) Vernier callipers is called after the name of......

(7) Screw gauge is so called because it can measure...distances with the help of the movement of a......

(8) Spherometer is so called because it is used for measuring ......

(9) Curvature of a spherical surface is equal to the......of its radius of curvature.

(10) Curvature of a plane surface is......

(11) Radius of curvature of a plane surface is......

(12) For any instrument, the sum total of its zero error and zero correction is......

(13) Study of Physics deals with two things only, namely......

(14) Whatever occupies space and possesses mass is known as.....

(15) ......is the hardest substance known.

(16) ... is the lightest substance known.

II. Select the instruments that you will use in order to accurately measure the following :

(1) A straight line.
(2) Diameter of a sphere.
(3) Diameter of a wire.
(4) Curvature of a surface.
(5) Volume of a drop of water.

III. Select the correct answer or answers from among the brackets, in the following :

(1) The smallest particle of an element that exhibits all the properties of the element is the......[molecule, electron, proton, atom]

(2) That which possesses mass and occupies space is best illustrated by...... [gravity, heat, matter, energy]

(3) The tendency of a liquid surface to contract is called...... [diffusion, surface tension. adhesion, viscosity]

(4) The force of attraction between unlike molecules is called ...... [diffusion, cohesion, adhesion, viscosity]

(5) The force of attraction between like molecules is called...... [diffusion, cohesion, adhesion, viscosity]

(6) If a metal rod can be drawn through a die to produce a wire, the metal is said to be...[malleable, tensile, ductile, crystalline]

(7) Dimension of pressure is......

[(*a*) $ML^{-1}T^{-2}$, (*b*) $ML^{-1}T^{-1}$, (*c*) $ML^{-2}T^{-1}$, (*d*) $M^{-1}LT^{2}$]

(8) Dimension of energy is......
[(*a*) $ML^{2}T^{-2}$, (*b*) $M^{2}LT^{-2}$, (*c*) $ML^{-2}T^{2}$, (*d*) MLT^{-1}]

(9) Dimension of force is......
[(*a*) $ML^{-1}T^{-2}$, (*b*) MLT^{-2}, (*c*) MLT^{-1}, (*d*) $M^{2}LT^{2}$]

(10) Which of the following equations is dimensionally correct ?

[(*a*) Pressure=Energry per unit volume.

(*b*) Pressure=Force per unit volume.

(*c*) Pressure=Energy per unit area.]

IV. Match the statements in column B with those in column A :

Column A	*Column B*
(1) Vernier Callipers	(*a*) used for measuring radius of curvature.
(2) Screw Gauge	(*b*) used for determining weight.
(3) Spherometer	(*c*) used for determining mass.
(4) Physical Balance	(*d*) used for measuring radius of wire.
(5) Volume* is measured by	(*e*) pipette, burette, graduated cylinder.
(6) Spring Balance	(*f*) used for measuring length.

---

*Stere is a unit of volume equal to one cubic metre.

CHAPTER II

VELOCITY AND ACCELERATION

I. Complete the following statements with proper word or words :

(1) Motion is the... ..of......of a body with respect to the surrounding objects.

(2) Speed* is the... ..of......of position of a body.

(3) Acceleration is the...of...of velocity.

(4) Velocity has both...and...

(5) When two bodies are equally accelerated, their relative acceleration is......

(6) When two bodies are equally accelerated, their relative velocity is ...

(7) The slope of the displacement-time graph gives......

(8) The slope of the velocity-time graph gives .....

(9) Momentum is the quantity of......that a body possesses and is measured by the product of its...and...

(10) $g=9{\cdot}8$ ..... $=980$...

(11) When a body is thrown vertically upwards, the velocity at the highest point is...

(12) A body is thrown upwards with an initial velocity of 40 cm/sec. Its velocity when it comes back to the same point is...

(13) Negative acceleration is called...

(14) A man sitting in a moving bus is at rest with respect to......

II. Select the correct statements :

(1) Rest and motion are

(*a*) absolute terms. (*b*) relative terms.

(2) The distance travelled by a body starting from rest and moving with uniform acceleration is

(*a*) directly proportional to the square of time.
(*b*) inversely proportional to the square of time.
(*c*) directly proportional to time.
(*d*) inversely proportional to time.

(3) A body is said to be moving with a uniform velocity, if it covers equal distances in

(*a*) equal intervals of time in the same direction.
(*b*) equal intervals of time in different directions.
(*c*) unequal intervals of time in the same direction.
(*d*) unequal intervals of time in different directions.

(4) When a body is thrown up, its velocity goes on

(*a*) increasing (*b*) decreasing (*c*) remains constant.

---

*Cusec = cu + sec = cubic + second. In reality cusec is a unit giving the speed of pumping of a pump. It is equal to one *cubic* foot per *second* but the pressure is not specified.

(5) A body moving with a uniform speed along a circular path
(*a*) has no acceleration. (*b*) has some acceleration.
(*c*) has a variable velocity. (*d*) none of the above.

(6) A body starting from rest, moves with an acceleration of 4 metres/sec^2. The distance travelled by it in 0.1 sec. is
(*a*) 4×10^{-2} metre. (*b*) 2×10^{-2} metre.
(*c*) 4×10^{-1} metre. (*d*) 2×10^{-1} metre.

(7) Acceleration is the rate of change of
(*a*) velocity, (*b*) direction, (*c*) speed, (*d*) none of these.

(8) A unit of acceleration is
(*a*) kilometres/sec. (*b*) ergs/minute^2
(*c*) inches/year^2 (*d*) cm./sec.

(9) Final velocity of an object starting from rest is equal to
(*a*) product of the acceleration and time.
(*b*) division of distance by the time.
(*c*) division of acceleration by the time.
(*d*) none of these.

(10) You observe an object covering distances in direct proportion to the square of time elapsed. What conclusion might you draw about its acceleration ? Is it
(*a*) increasing. (*b*) decreasing, (*c*) zero, (*d*) constant ?

(11) The displacement *s* of a particle along a st. line at time *t* is given by $s=p+q.t+r.t^2$. The acceleration of the particle is
(*a*) p (*b*) q (*c*) r (*d*) $2.r$

(12) A man goes on pilgrimage. Half the distance he covers on foot with an average speed of 10 km./hour and the other half by a mail train at an average speed of 40 km./hour. The average speed for the whole journey was
(*a*) 25 km./hour ; (*b*) 20 km./hour ;
(*c*) 18 km./hour ; (*d*) 16 km./hour.

(13) At what angle to the horizontal should a ball be kicked to attain maximum distance ?
(*a*) 0°, (*b*) 30°, (*c*) 45°, (*d*) 90°.

III. Pick out the correct statements :

(1) There is no body at absolute rest or in absolute motion.

(2) The earth moves round the sun with a uniform velocity.

(3) The angular velocity of a rotating body is the angle described by it in a unit time.

(4) Bodies fall with a variable acceleration.

(5) A body which seems to be at rest to one person, may seem to be in motion to another.

(6) With zero acceleration, the speed of your bus would neither increase nor decrease.

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(7) Bodies rise up because sky is their natural abode.

(8) Time is stated twice in stating acceleration because acceleration is the rate of change of velocity.

(9) A cyclist runs along a circular path and covers 15 metres in every second. It is moving with a constant velocity.

(10) The formula $s=u.t+\frac{1}{2}a.t^2$ is true only if the acceleration is uniform.

(11) The slope of the velocity-time graph gives acceleration.

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CHAPTER III

RESULTANT AND COMPONENT VELOCITIES

I. Complete the following statements with proper word or words :

(1) The rectangular components of a velocity are......

(2) If a particle is acted upon simultaneously by two velocities, their resultant is given by the Law of...

(3) The path traced by a stone dropped from the window of a helicopter when it is stationary is a......and when it is in motion in a horizonal direction, it is a .....

(4) The time taken by a stone thrown vertically upward is...... the time it will take when it falls down freely from the same height.

(5) The resultant of two velocities inclined at an angle can be found by......

(6) If a number of coplanar velocities act at a particle in different directions, their resultant can be found by......

(7) Resultant velocity $R=\sqrt{u^2+\dots\dots\dots}$

(8) Direction of the resultant velocity is given by $\tan\beta=\frac{\dots\dots\dots}{\dots-\dots}$

(9) When two velocities are perpendicular to each other, their resultant is given by $R=\sqrt{\dots\dots\dots}$

(10) Two equal velocities, each equal to u, act on a particle at an angle of 60°. Their resultant is......

(11) Sum and difference of two vectors which are perpendicular to each other and equal in magnitude are inclined to each other at an angle of......

II. Select the correct completion for each of the following questions :

(1) One of the rectangular components of a velocity which makes an angle of 45° with it is 20 metres an hour ; the other component is

(*a*) 10 m/hr., (*b*) 20 m/hr., (*c*) $20\sqrt{2}$ m/hr.

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(2) A body possesses two equal velocities, each equal to 10 metres per hour, at an angle of 45°. Their resultant is

(*a*) $10\,(2+\sqrt{2})$ m/hr. (*b*) $10\sqrt{(2+\sqrt{2})}$ m/hr.

(*c*) $100\,(2+\sqrt{2})$ m/hr.

(3) A truck travelling due north at 20 metres/sec. turns west and travels at the same speed. The change in the velocity of the truck is

(*a*) 40 m/sec. north-west ;

(*b*) $20\sqrt{2}$ m/sec. north-west ; (*c*) no change.

(4) Ball *A* is dropped vertically. Another ball *B* is projected horizontally with a certain velocity from the same point at the same instant. Then

(*a*) *A* will strike the ground earlier than *B*.

(*b*) *B* will strike the ground earlier than *A*.

(*c*) both will strike the ground at the same instant.

(5) A boatman wants to take his boat to a point just opposite on the other bank of the river. Then

(*a*) he should row up-stream.

(*b*) he should row down-stream.

(*c*) he should row at right angles to the bank.

(*d*) he should row inclined to the bank up-stream.

(*e*) he should row inclined to the bank down-stream.

(6) A hunter aims at a monkey sitting on a tree at a considerable distance. At the instant he fires at it, the monkey drops. Will the bullet hit the monkey ?

(*a*) No (*b*) Yes

(7) A car is moving on a road when the rain is falling vertically downwards. Then

(*a*) rain will strike the hind screen.

(*b*) rain will strike the front screen.

(*c*) rain will not strike the front or the hind screen.

(*d*) rain will strike both the screens.

(8) A man wants to hit a target, so he should point his rifle

(*a*) higher than the target. (*b*) lower than the target.

(*c*) in the same direction as the target.

CHAPTER IV

LAWS OF MOTION

I. Complete the following statements with proper word or words :

(1) A passenger standing in a bus falls......when the bus starts suddenly.

(2) A passenger standing in a bus falls......when the bus stops suddenly.

(3) Weight of a body is......towards the centre of earth.

(4) A force of 2 lb. wt. acting on a body of mass 2 lb. produces in it an acceleration of...ft./sec^2.

(5) When the unit of mass is 1 kg. and unit of acceleration* 1 metre/sec^2., the unit of force is called a......

(6) According to the law of conservation of momentum,

$$m_1u_1+\ldots\ldots=m_1v_1+\ldots\ldots$$

(7) Impulse =......=......

(8) 1 kg. wt.=...newtons.

(9) Momentum is the...possessed by a body.

(10) The *inability* of a body to change by itself its state of rest or of uniform motion in a st. line is called......

II. Fill suitable words in the blanks from the list given in brackets :

(1) Inertia is the property of...due to which it...
[mass, matter, volume, reacts, opposes any change]

(2) ...is the property of matter due to its...
[velocity, motion, momentum, acceleration]

(3) A unit of force is the force which generates a unit......in a unit... [acceleration, velocity, mass, speed]

(4) To every...there is an...and opposite...
[reaction, opposite, action, weight, double, equal]

(5) The first law of motion gives us...of force.
[measurement, definition, time]

(6) The second law of motion gives us how force can be.....
[known, defined, measured, drawn]

(7) Forces...measured by the acceleration they produce.
[are, are not]

(8) Momentum generated in a moving mass......proportional to the impulse causing motion. [is, is not]

(9) A body, acted upon by a constant force, has a velocity increasing by..... amounts in equal distances. [unequal, equal]

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*An acceleration of one foot/sec^2 is called a celo.

(10) It is... ..to tow a boat along a canal, from the footpath, by using a long rope rather th an a short one. [easier, more difficult]

(11) It is rather......to break a tightly stretched string by pulling at it sideways. [easy, difficult]

(12) A gun recoils on firing due to......law of motion. [1st, 2nd, 3rd]

(13) Swimming is possible on account of......law of motion. [1st, 2nd, 3rd]

(14) Force is a —...quantity. [scalar, vector]

(15) The cleaning of dirty carpet by beating depends upon...... law of motion. [1st, 2nd, 3rd]

III. Choose the correct completions for the following statements :

(1) The statement that 'a book lying on a table will remain there for ever' is based upon

(*a*) 1st law ; (*b*) 2nd law ; or (*c*) 3rd law of motion.

(2) The statement that in a rocket the hot gases shoot out backwards but the rocket moves forward is based upon

(*a*) 1st law ; (*b*) 2nd law ; or (*c*) 3rd law of motion.

(3) When we jump out of a stationary boat, the boat

(*a*) moves forward ; (*b*) moves backward ;
(*c*) remains stationary.

(4) Two trains *A* and *B* are running in the same direction on parallel tracks, such that *A* is faster than *B*. If packets of equal weights are exchanged between the two, then

(*a*) *A* will be accelerated but *B* retarded.
(*b*) there will be no change in *A* but *B* will be accelerated.
(*c*) there will be no change in *A* but *B* will be retarded.
(*d*) there will be no change in *B* but *A* will be accelerated.
(*e*) there will be no change in *B* but *A* will be retarded.
(*f*) *A* will be retarded but *B* will be accelerated.

(5) A mass of 5 gm. is acted upon by a force which changes its velocity from 50 to 250 cm./sec. in 2 seconds. The force required is

(*a*) 0·50 dyne (*b*) 0·50 gm. wt. (*c*) 500 dynes (*d*) 500 gm. wt.

(6) A newton is

(*a*) 1 gm.$\times$cm./sec^2 (*b*) 1 kg.$\times$cm./sec^2.
(*c*) 1 kg.$\times$m/sec^2. (*d*) 1 gm$\times$cm.$\times$sec^2.

(7) A 5 kg. wt. is accelerated from rest to 60 metres/sec. The force acting on it is

(*a*) 5×60 newtons ; (*b*) $5\times60\times9{\cdot}8$ newtons ;
(*c*) $60^2\times(5/2)$ newtons : (*d*) $60^2\times(5/2)\times9{\cdot}8$ newtons ;
(*e*) not enough information.

(8) The product of a force and the length of time is called
(*a*) momentum (*b*) impulse (*c*) intertia (*d*) none of these.

(9) A body whose momentum is constant
(*a*) must always be accelerated.
(*b*) must always be retarded.
(*c*) must always have a constant velocity.

(10) A lead ball strikes a wall and falls down. A tennis ball having the same mass and velocity strikes the wall and bounces back. We conclude that
(*a*) the momentum of the lead ball is greater than that of the tennis ball.
(*b*) the lead ball suffers a greater change in momentum compared with the tennis ball.
(*c*) the tennis ball suffers a greater change in momentum compared with the lead ball.
(*d*) both suffer an equal change in momentum.

(11) When a horse pulls a cart, the force that causes the horse to move forward is the force
(*a*) he exerts on the cart. (*b*) the cart exerts on him.
(*c*) he exerts on the ground. (*d*) the ground exerts on him.

(12) When a force of 1 newton acts on a body of mass 1 kg., then the body will move with
(*a*) a speed of 1 m/sec.
(*b*) an acceleration of 0·1 m/sec^2.
(*c*) an acceleration of 1 m/sec^2.
(*d*) an acceleration of 9·8 m/sec^2.

(13) A force acts on a body that is free to move. If we know the magnitude and direction of the force and the mass of the body, Newton's second law of motion enables us to determine the body's
(*a*) weight (*b*) speed (*c*) velocity (*d*) acceleration.

(14) A unit force is that much force which produces
(*a*) unit acceleration in a unit mass.
(*b*) unit velocity in a unit time in a unit mass at rest.
(*c*) a unit change in the momentum of a body in a unit time in its own direction.

(15) Absolute unit of force is
(*a*) dyne (*b*) poundal (*c*) newton (*d*) kg. wt.

(16) Engineering unit of force is
(*a*) gm. wt. (*b*) lb. wt. (*c*) kg. wt. (*d*) newton.

(17) Impulse is measured in the units of
(*a*) ergs (*b*) poundal × sec. (*c*) lb. wt. × sec. (*d*) newton.

(18) $\frac{\text{gm. cm.}}{\text{sec}^2}$ stands for the unit of

(*a*) force ; (*b*) acceleration ;
(*c*) momentum ; (*d*) angular momentum.

(19) A weight is suspended from the middle of a rope whose ends are at the same level. In order for the rope to be perfectly horizontal the forces applied to the ends of the rope

(*a*) must be equal to the weight.
(*b*) must be greater than the weight.
(*c*) must be so great that the rope is on the point of breaking.
(*d*) must be infinite which is practically impossible.

(20) A bullet hits and gets embedded in a solid block resting on a horizontal frictionless table. What is conserved ?

(*a*) Momentum alone. (*b*) Kinetic energy alone.
(*c*) Momentum and kinetic energy both.
(*d*) Neither momentum nor kinetic energy.

(21) A jet engine works on the principle of conservation of

(*a*) mass. (*b*) energy.
(*c*) linear momentum. (*d*) angular momentum.

(22) A particle at rest suddenly disintegrates into two particles of equal masses which start moving. The two fragments will

(*a*) move in the same direction with equal velocities.
(*b*) move in any two directions with any velocities.
(*c*) move in opposite directions with equal velocities.
(*d*) move in opposite directions with unequal velocities.

IV. Match the statements in column B with those in column A :

Column A	*Column B*
(1) Inertia	(*a*) It is a unit of force in the M.K.S. system.
(2) Weight	(*b*) A physical balance measures
(3) Impulse	(*c*) A spring balance measures
(4) Mass	(*d*) The force of short duration.
(5) Newton	(*e*) The inability of matter to change by itself its state of rest or of uniform motion in a straight line.

CHAPTER V

CIRCULAR MOTION

I. Complete the following statements with proper word or words :

(1) In a circular motion a body moves with......speed but with......velocity.

(2) If the speed of earth increases, the weight of bodies......

(3) When a man cycles on a muddy road, mud flies off the fast moving wheels because of .....force.

(4) When a knife is pressed against a grinding stone, the sparks fly off......

(5) When a cyclist takes a turn, he leans......

(6) Centrifugal force is equal to......force.

(7) Centrifugal force is directed......the centre.

(8) Centripetal force is directed......the centre.

II. Select the correct answer or answers for each of the following questions or statements :

(1) Formula for the centripetal force is

(*a*) mv/r (*b*) mr/v (*c*) mv^2/r (*d*) mv/r^2

(2) When a body rotates along a circle, the force which keeps it moving with a uniform speed is called

(*a*) gravitational force.
(*b*) centripetal force.
(*c*) centrifugal force.
(*d*) electrostatic force.
(*e*) magnetic force.

(3) A motor cyclist going around a circular track at a constant speed

(*a*) has a constant linear velocity.
(*b*) has a constant acceleration.
(*c*) has an acceleration of constant magnitude.
(*d*) has a varying angular acceleration.

(4) When a mass is rotating in a plane about a fixed point, its momentum is directed along

(*a*) the axis of rotation.
(*b*) the radius.
(*c*) the tangent to the radius.

(5) A cyclist taking a turn bends inwards while a car passenger taking the same turn is thrown outwards. The reason is

(*a*) the difference in the masses of the two.
(*b*) the difference in the speeds of the two.
(*c*) that car has four wheels while cycle has only two.
(*d*) that the cyclist has to counteract the centrifugal force while the car passenger is only thrown by it.

(6) If the radius of earth is 6400 km., the linear velocity of a point on the equator is nearly

(*a*) 1600 km./hour. (*b*) 800 km./hour.
(*c*) 200 km./hour. (*d*) 100 km./hour.

III. State whether the given statements are correct or false :

(1) Centripetal force is directed away from the centre.

(2) Centripetal force is directed towards the centre.

(3) Centrifugal force is directed away from the centre.

(4) Centrifugal force is directed towards the centre.

(5) Centripetal and centrifugal forces are equal and opposite.

(6) Centripetal force comes in when a body rotates in an anti-clockwise direction while centrifugal force comes in when a body rotates in a clockwise direction.

(7) A cyclist, while turning a corner, leans outwards.

(8) The weight of the bodies would be greater if the earth stops rotating.

(9) A particle moving along an arc is not moving under the influence of a force.

(10) In laundries, the clothes are dried, by revolving the drum at high speed, due to centripetal force.

(11) Planets revolve round the sun due to centripetal force provided by the gravitational attraction between the sun and planets.

(12) When a bucket full of water is kept revolving at a high speed, water does not fall overhead due to centripetal force.

(13) When a car goes round a curve on a level road, the centripetal force is provided by the force of friction between the road and the tyres.

(14) For a given radius of a curved track, one particular angle of banking is not correct for all velocities.

CHAPTER VI

GRAVITATION, GRAVITY AND PENDULUM

I. Complete the following sentences by suitable words or word :

(1) The force with which a body is attracted by the earth is called......

(2) Acceleration of a particle due to the earth's gravity......on the mass of the particle.

(3) The time period of a simple pendulum depends on its length when.........is constant.

(4) The time period of a simple pendulum is inversely proportional to the square root of g when......is constant.

(5) To correct a clock that is going slow, the length of the pendulum has to be......

(6) The value of g at a place on the surface of earth increases as its distance from the centre of the earth......

(7) The value of g will......if the earth stops rotating.

(8) Time period of a second's pendulum is......second or seconds.

(9) A body weighs......at the poles than at the equator.

(10) The value of g is determined in the laboratory by......

(11) Mass of a body is measured by means of a......balance while the weight of a body is measured by means of a......balance.

(12) The quantity of matter contained in a body is called its......

(13) Gravity is the force of attraction between......and any other object on or around it.

(14) Mass remains......everywhere.

II. Select the proper words from the brackets to fill in the blanks :

(1) Every material body exerts a force of......towards every other material body. [attraction, repulsion]

(2) Force of gravitation between two bodies is directly proportional to the..... of their masses. [square, product]

(3) Force of gravitation between two bodies is inversely proportional to the......of distance between......
[square, product, them, their centres]

(4) Inertial mass is......to gravitational mass of a body.
[equal, not equal]

(5) Force of gravity will be......on one kg. of iron than on $\frac{1}{2}$ kg. of silver. [larger, smaller]

(6) An iron ball and a wooden ball of the same radius are released from the same height *in vacuum*. The times taken by both of them to reach the ground are......
[unequal, exactly equal, roughly equal]

(7) An iron ball and a wooden ball of the same mass are released from the same height *in air*. Then...

[(*a*) the iron ball will hit the ground earlier.

(*b*) the wooden ball will hit the ground earlier.

(*c*) both the balls will hit the ground at the same time.]

(8) ......discovered that the earth moves round the sun. [Copernicus, Galileo, Newton]

(9) Time period of a simple pendulum will......when taken from equator to the poles. [increase, decrease]

(10) Time period of a simple pendulum will .....when taken to the top of a hill. [increase, decrease]

(11) Time period of a simple pendulum will......when taken inside a deep mine. [increase, decrease]

(12) A pendulum clock will become.....when taken inside a deep mine. [fast, slow]

(13) Length of a simple pendulum is doubled. Its time period will change in the ratio of......to 1. [$1/\sqrt{2}$, 2, 1/2, $\sqrt{2}$]

(14) A pendulum clock will become......in water when it was regulated in summer. [fast, slow]

(15) The spaceman in his rocket just after it is fired and is picking up speed feels...... [normal weight, lighter, heavier, weightless]

III. Select the correct answer or answers for each of the following questions or statements :

(1) Rain drops fall from a great height under gravity. We observe that

- (*a*) their velocities go on increasing until they hit the earth with the same final velocity.
- (*a*) their velocities go on increasing as they hit the earth, but final velocities of different sized drops are different.
- (*c*) they fall with a terminal velocity which is same for every drop.
- (*d*) they fall with terminal velocities which are different for drops of different sizes.

(2) The escape velocity on earth is about 11 km./sec. ; on moon it is

(*a*) larger. (*b*) smaller. (*c*) the same.

(3) A motor cyclist rides around a well with a round vertical wall and does not fall down while riding. Obviously

- (*a*) the force of gravity disappears.
- (*b*) he loses his weight somehow.
- (*c*) the frictional force of the wall balances his weight.

(4) There is a body lying on the surface of earth and suppose that the earth suddenly loses its power of attraction. Then

- (*a*) the mass of the body will become zero.
- (*b*) the weight of the body will become zero.

(*c*) both (mass and weight) will vanish.

(*d*) the mass will remain same but weight will vanish.

(*e*) the weight will remain same but mass will vanish.

(5) A body is taken from the equator to the poles. Then

(*a*) mass of the body will change.

(*b*) weight of the body will change.

(*c*) both (mass and weight) will change.

(*d*) mass will remain same but weight will change.

(*e*) weight will remain same but mass will change.

(6) Moon has a mass of 1/80th of that of earth and is 1/4th in diameter to that of the earth. The weight of a man on the moon will be......that on the earth.

(*a*) same as ; (*b*) 1/5th of ;

(*c*) 1/4th of ; (*d*) 1/2 of.

(7) Moon has a mass of 1/80th of that of earth and is 1/4th in diameter to that of the earth. At a certain point in the flight, the resultant force due to the earth and the moon on a spaceship will be zero. This point will divide the earth-moon distance approximately in the ratio of

(*a*) 1 : 1, (*b*) 5 : 1, (*c*) 9 : 1, (*d*) 80 : 1.

(8) Ordinarily we use the value of g as

(*a*) 32 ft./sec^2 (*b*) 32 ft./min^2 (*c*) 32 inches/sec^2

(*d*) 32 cm./sec^2 (*e*) 32 metres/sec^2 (*f*) 98 cm./sec^2

(*g*) 9·8 metres/sec^2 (*h*) 980 ft./sec^2 (*i*) 980 ft./hour^2.

(9) Time period of a simple pendulum depends upon

(*a*) its length ; (*b*) mass of the bob ;

(*c*) value of g at that place ; (*d*) its amplitude.

(10) Time period of a simple pendulum can be increased by

(*a*) increasing the arc of the swing ;

(*b*) increasing the length of the pendulum ;

(*c*) increasing the mass of the bob ;

(*d*) increasing the thickness of the string.

(11) Time period of a simple pendulum can be decreased by

(*a*) increasing the arc of the swing ;

(*b*) increasing the length of the pedulum ;

(*c*) increasing the mass of the bob ;

(*d*) increasing the thickness of the string.

(12) When a body is supposed to be falling freely under gravity, then its acceleration depends upon

(*a*) mass of the body. (*b*) mass of the earth.

(*c*) speed of rotation of earth.

(13) A hole is drilled through the earth along its diameter and a stone is dropped into it. When the stone is at the centre of the earth, it possesses

(*a*) mass ; (*b*) weight ; (*c*) acceleration ;
(*d*) potential energy ; (*e*) kinetic energy.

(14) If the tension in the cable of 1000 kg. elevator is 1000 kg. weight, the elevator

(*a*) is accelerating upwards ;
(*b*) is accelerating downwords ;
(*c*) may be at rest or accelerating ;
(*d*) may be at rest or decelerating.

(15) When the bob of a swinging pendulum momentarily comes to rest in one extreme position, its energy is

(*a*) destroyed ;
(*b*) converted to potential energy ;
(*c*) converted to kinetic energy ;
(*d*) converted to heat energy.

(16) What will happen, out of the four alternatives given above in Q. (15) when the swing dies down and the pendulum stops ?

(17) The time period of a second's pendulum is 2 sec. The spherical bob which is empty from inside has a mass of 50 gm. This is now replaced by another solid bob of the same radius but having a different mass of 100 gm. The new time period will be

(*a*) 1 sec ; (*b*) 2 sec ; (*c*) 4 sec ; (*d*) 8 sec.

(18) Two bodies of different masses m_1 and m_2 are dropped from two different heights a and b respectively. The ratio of times taken by the two to drop through these heights is

(*a*) $a^2 : b^2$; (*b*) $a : b$; (*c*) $b : a$; (*d*) $\sqrt{a} : \sqrt{b}$.

IV. Match the statements in column B with those in column A :

Column A	*Column B*
(1) Gravitation is	(*a*) the force of attraction between earth and any other object.
(2) A spring balance measures	(*b*) the mass of an object.
(3) At a given place	(*c*) the force of attraction between any two abjects in the universe.
(4) Gravity is	(*d*) the mass and the wt. of the same object are proportional to each other.
(5) A physical balance measures	(*e*) the weight of an object.

CHAPTER VII

WORK, POWER & ENERGY

I. Complete the following statements with suitable word or words :

(1) ......is an absolute unit of work in C.G.S. system.

(2) Joule is the unit of......in......system.

(3) 10^7 ergs=...joule.

(4) 1 Horse Power*=......watts.

(5) Potential energy is due to the......of a body.

(6) Kinetic energy is due to the......of a body.

(7) A moving person possesses......energy.

(8) A body on the top of a tower possesses......energy.

(9) The capacity of doing work is called......and the rate of doing work......

(10) One kilowatt-hour=......joules.

(11) One kilogram-metre=......joules.

(12) A compressed spring and a stretched wire have......energy.

(13) Spring in a watch, after winding, possesses......energy.

II. Select suitabls word or words to complete the following sentences from the clues provided against each :

(1) Watt is the unit of...... [force, work, energy, power]

(2) Erg is the unit of...... [force, work, power, energy]

(3) Dyne-sec. stands for the unit of...... [force, work, momentum, angular momentum]

(4) The units of energy are same as those of...... [work, power, force]

(5) ......is the rate of doing work. [Energy, Power, Momentum]

(6) The kind of mechanical energy stored in a dam is...... [K.E., P.E.]

(7) A stone is dropped from a tower ; its total energy...... during its fall. [increases, decreases, remains constant]

(8) When a body is moved from rest by a constant force through a given space, K.E. of the body is......the work done by the force. [less than, equal to, greater than]

(9) A body of mass of 10 lb. is moving with a velocity of 5 ft./sec. ; its kinetic energy is ..... [125 ft.lb. ; 125 ft. poundals ; 250 ft. poundals ; 250 ft.lb.]

(10) A body of mass 2 gm. is at a height of 10 metres. Its potential energy is...... [1960000 joules, 1960000 ergs, 200 ergs, 20 joules, 196 joules]

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*1 Donkey Power=250 watts.

(11) A boy performs the operations listed below. Indicate the order of the greatest work done by him to the least work done by him. (Wt. of boy=50 kg. ; wt. of brick=1 kg.) :

(*a*) Boy lifts the brick from the ground to a table 1 metre high.

(*b*) Boy carries the brick up a ladder to a vertical height of 5 metres.

(*c*) Boy steps from the floor to the table 1 metre high.

(*d*) Boy runs up a flight of 25 steps, each step being 20 cm. high.

(*e*) Boy raises the brick to a vertical height of 5 metres by means of a single fixed pulley.

(*f*) Boy exerts a force of three quarters of a kg. to push the brick to a distance of 5 metres.

(12) In a collision between two bodies, their

(*a*) momentum is always conserved.

(*b*) momentum is not conserved.

(*c*) kinetic energy is always conserved.

(*d*) kinetic energy is not conserved.

(13) Three aeroplanes *A*, *B* and *C* of equal weights are flying at velocities 200 km,, 500 km. and 1000 km. per hour and at altitudes 10000 metres, 4000 metres and 2000 metres respectively. Then

(*a*) *A* has the maximum potential energy.

(*b*) *B* has the maximum potential energy.

(*c*) *C* has the maximum potential energy.

(*d*) their potential energies are equal.

(14) A jet engine works on the principle of

(*a*) conservation of mass. (*b*) conservation of energy.

(*b*) conservation of linear momentum.

(15) Which of the following statements is true ?

(*a*) Only matter can be converted into energy.

(*b*) Only energy can be converted into matter.

(*c*) Matter can not be converted into energy.

(*d*) Matter and energy are inter-convertible.

(16) When a body moves with a high speed, its mass

(*a*) disappears. (*b*) decreases.

(*c*) remains constant. (*d*) increases.

CHAPTER VIII

FRICTION

I. Complete the following statements with suitable word or words :

(1) Static friction is......than dynamic friction.

(2) Friction is a......adjusting......

(3) Maximum value of friction called into play is called......

(4) The value of limiting friction is directly proportional to the...... between the surfaces.

(5) Tangent of angle of friction is equal to......

(6) Friction is due to......

(7) Friction can be reduced by......

(8) Coefficient of friction is defined as the ratio of......

(9) Friction is both a necessity and an......

(10) The force of friction always acts in such a direction that......

(11) The limiting friction is independent of......and depends on......

(12) $F=\mu\times......=......\times \tan\theta$

II. Choose the correct word or words given within brackets to complete the following statements :

(1) Friction has......existence of its own.
[independent, no independent]

(2) Rolling friction is......static friction.
[greater than, less than, equal to]

(3) The angle of friction is the angle which the resultant of the limiting friction and normal reaction makes with the direction of......
[friction, normal reaction]

(4) The magnitude of friction......the velocity provided it is not large. [depends upon, is independent of]

(5) The limiting friction is......proportional to normal reaction.
[directly, inversely]

(6) The friction acts in the......direction to the direction of motion. [same, opposite, perpendicular]

(7) A man is trying to displace a block of stone lying on the ground by pushing it hard from one side. The stone does not move because......

[(*a*) the frictional force is greater than the force applied by the man.

(*b*) two equal and opposite forces are acting on the stone.

(*c*) only frictional force is acting on the stone.]

(8) A child sits on a sledge which is dragged by a dog over a certain distance on a frozen pond. Choose the data you would require in order to calculate the work done in pulling the sledge :

[(*a*) Weight of child. (*b*) Weight of dog.
(*c*) Weight of sledge. (*d*) Force of friction opposing motion.
(*e*) Distance moved by sledge.
(*f*) Distance moved by dog.
(*g*) Force required to move the sledge to the given distance.]

(9) Friction between moving bodies is......their relative velocity. [dependent upon, independent of]

(10) A horse will get a......grip on a slippery road by mounting a man on its back. [better, worse, no change of]

(11) A billiard player will make a......shot by marking the end of his cue with chalk. [better, worse, no change of]

(12) Coefficient of friction between any two surfaces......be equal to zero. [can, cannot]

III. Match the statements in column A with those of column B :

Column A	*Column B*
(1) Friction can be reduced by	(*a*) coefficient of friction.
(2) μ is defined as	(*b*) $\sqrt{r.\ x}$
(3) Tangent of the angle of friction is equal to	(*c*) 0·1
(4) A bend on a level road has a radius r and μ between car and road is x ; then maximum speed of car is	(*d*) lubricants. (*e*) $\sqrt{r/x}$ (*f*) 10
(5) A force of 25 lb. wt. is required to pull a sledge weighing 250 lb. over ice ; the μ of ice is	(*g*) the ratio of the limiting friction to the normal reaction.

CHAPTER IX

FORCES ON RIGID BODIES

I. Complete the following statements with suitable word or words :

(1) A rigid body is one whose size......, whatever force be applied to its different parts.

(2) When a body moves as a whole from one place to another, it has a motion of......

(3) When a body turns round a fixed axis, it has a motion of......

(4) The tendency of a force to rotate a body about an axis is called its......

(5) Moment of the force acting on a body is equal to the product of the force and......

(6) Two equal, parallel and opposite forces acting along different lines of action on a rigid body constitute a......

(7) The......moments are taken as positive while......moments are negative.

(8) The principle of moments states that......

(9) A body, when it remains at rest under the action of two or more forces acting simultaneously, is said to be in......

(10) A body is said to be in equilibrium when its acceleration is......

(11) The point in a body where its whole weight acts is called its......

(12) The stability of a body can be increased by......its centre of gravity.

(13) The C.G. of a body is neither raised nor lowered in the case of......equilibrium.

II. Fill in the blanks or complete the statements with suitable words selected from those given in brackets :

(1) For stable equilibrium, the base of the body should be as......as possible. [small, large]

(2) When a body in unstable equilibrium is disturbed, its C.G. is...... [raised, lowered]

(3) A cart carrying one quintal of iron is upset......than a cart full of one quintal of loose cotton. [more easily, less easily]

(4) When you are climbing up a mountain, you bend...... [forward, backward]

(5) A body topples over when the vertical line through its C.G. falls......its base. [outside, inside]

(6) Positions of centre of gravity and centre of mass of a body are...... [identical, different]

(7) Moment of a force is a......quantity. [scalar, vector]

(8) Resultant of two like parallel forces acts......the points of application of the two forces. [within, outside]

(9) Resultant of two unequal and unlike parallel forces acts......the points of application of the two forces. [within, outside]

III. For each of the following statements, several answers or completions have been given. Select the correct completions :

(1) The stability of an object may be increased by

(*a*) enlarging the base ; (*b*) raising the centre of gravity ;
(*c*) reducing the base ; (*d*) increasing the height.

(2) A person, carrying a bucket full of water in his right hand, leans

(*a*) towards his left hand ; (*b*) towards his right hand :
(*c*) does not lean at all.

(3) While carrying a load on his back, a man leans

(*a*) forward ; (*b*) backward ; (*c*) does not lean at all.

(4) For stable equilibrium, the C.G. of a body should be

(*a*) high, (*b*) low.

(5) Lead or mercury is used in the lower part of a hydrometer to

(*a*) raise its C.G. ; (*b*) lower its C.G.

(6) Two heavenly bodies A and B, not far off from each other, are seen to revolve in orbits

(*a*) which are arbitrary ;
(*b*) around their common centre of mass ;
(*c*) with A fixed and B moving around A ;
(*d*) with B fixed and A moving around B.

IV. Pick out the correct and incorrect statements :

(1) The leaning tower of Pisa does not fall because its top is very light.

(2) The higher the C.G., the more stable a body is.

(3) A couple cannot be balanced by a single force.

(4) The moment of a couple is the same about all points in its plane.

(5) Two couples of equal and opposite moments in the same plane balance each other.

(6) A force has a definite point of application, whilst a couple has not.

(7) It is easier to open the cap of a pen with the help of two fingers than with one finger.

(8) A rope-dancer holds an umbrella or a pole to balance himself.

(9) While coming down the hill, a person leans backward.

(10) Trucks, cars and ships are made with their bottom heavy to keep them in stable equilibrium.

(11) Magnitude of moment of a force can be represented by twice the area of the triangle whose base is the given force and altitude is the arm of the force.

CHAPTER X

MACHINES

I. Complete the following statements with suitable word or words :

(1) Mechanical Advantage (M.A.) of a machine is the ratio of......and......

(2) Velocity Ratio (V.R.) of a machine is the ratio of the distance moved through by the......to the distance moved through by the......

(3) Efficiency of a machine is the ratio of......to......

(4) Mechanical Advantage=Efficiency × ......

(5) In an actual machine, velocity ratio is always......than mechanical advantage.

(6) In the case of a Screw Jack, its V.R.=......

(7) In the case of a Wheel and Axle. its V.R.=......

(8) In the case of a Differential Pulley, its V.R.=......

(9) In the case of a Wedge, its V.R.=......

(10) In the case of a Single Fixed Pulley, its V.R.= ......

(11) A pulley changes the......of the applied force.

(12) In a machine, what is gained in effort is lost in......

(13) A balance which is stable cannot be......

(14) In the second order of levers, weight is placed......

(15) The mechanical advantage of a single movable pulley is... while that of a single fixed pulley is......

II. Select the suitable words from the brackets to fill up the blanks :

(1) Efficiency of a perfect machine is......
[less than 1, 1, more than 1]

(2) In a perfect machine, mechanical advantage is equal to......
[efficiency, velocity ratio, input, output]

(3) In an actual machine, the input is......the output.
[more than, less than, equal to]

(4) Balance is a lever of......order. [1st, 2nd, 3rd]

(5) Lemon-squeezer is a lever of......order. [I, II, III]

(6) A pair of forceps is a lever of......order. [I, II, III]

(7) Cork-presser is a lever of......order. [I, II, III]

(8) A pair of scissors is a lever of......order. [I, II, III]

(9) A lever which always gives a gain in force is of...... order. [I, II, III]

(10) A lever which always gives a gain in distance is of......order. [I, II, III]

(11) When our body stands on tip-toe, the class of lever which is used is...... [I, II, III]

(12) The heel being previously raised from the ground, the foot is extended so that the toe taps the ground; then the class of lever which is used is...... [I, II, III]

(13) It is......to push a wheelbarrow over a bump in the road if the handles of the wheelbarrow are lowered. [easier, more difficult]

(14) Efficiency of an ideal Wheel and Axle is...... [1, 2, 3]

(15) A lever helps you to do work because it......

[(*a*) decreases the weight to be lifted.
(*b*) increases the force you can apply.
(*c*) moves the weight a long distance.
(*d*) has a fulcrum.]

III. Pick out the correct statements :

(1) In an ideal machine, mechanical advantage is less than velocity ratio.

(2) Machines are used to change the slow motion at one point into a rapid motion at another point.

(3) We get more work from a machine than given to it.

(4) In an actual machine, output is less than input.

(5) A balance can be stable and sensitive at the same time.

(6) The arms of a balance are in the ratio of 10 : 1. The customer will lose if the shopkeeper places the goods in the pan of longer arm and weighs it.

(7) When a bicycle is ridden, the speed of the bicycle (or its wheels) is much greater than the speed of the cyclist's feet. Hence M.A. of the bicycle is less than one.

(8) The steering wheel of a car is an example of wheel and axle.

(9) The stone-steps of a down-flight in a school are more worn than those of the up-flight, although both flights are equally used.

CHAPTER XI

ELASTICITY, SURFACE TENSION AND VISCOSITY

I. Complete the following statements with suitable word or words :

(1) Elasticity is defined as the property by virtue of which a body regains its original dimensions when the......are removed.

(2) Stress is defined as the......force per unit area.

(3) The ratio of the change in shape to original shape is called .....

(4) Strain has......units.

(5) The absolute C.G.S. unit of stress is......

(6) The absolute C.G.S. unit of Young's modulus of elasticity is......

(7) The......is the tangential force per unit area.

(8) Due to surface tension, the liquid surface has a tendency to......

(9) The oil rises in wicks (of lamps) because the space between the threads acts as......

(10) In plants, the moisture reaches the branches and leaves partly due to the action of......

(11) The nib of the pen is split at the tip because the slit......

(12) A large number of pores in a blotting paper forms......and the ink is drawn up through these pores.

(13) The shape of water meniscus in a glass capillary tube is...... while that of mercury is......

(14) When several non-miscible liquids are poured into a vessel, their common surfaces (for any two layers) are......

(15) Water is......in a glass capillary tube whereas mercury is...... in it.

(16) For water, the angle of contact is almost......

(17) Mercury does not wet the glass because the force of...... between the mercury molecules is much more than the force of...... between the glass and water molecules.

(18) Water wets glass because the force of adhesion between...... is more than the force of cohesion between......

(19) A river flows......in the middle than at the sides near the banks.

(20) The viscous retarding forces of a liquid or gas......with the velocity of the object.

II. Fill in the blanks with suitable words from the brackets :

(1) Within the elastic limit, stress is .....to strain.
[equal, inversely proportional, directly proportional]

(2) Which is more elastic ?...... [rubber or steel]

(3) Young's modulus of elasticity is equal to......
$\left[\frac{F.L}{A.l}, \frac{F.l}{A.L}, \frac{F.A}{l.L}\right]$

(4) Modulus of rigidity is equal to...... $\left[\frac{F}{a.\theta}, \frac{F.\theta}{a}, \frac{\theta}{F.a}\right]$

(5) Bulk modulus is equal to...... $\left[\frac{p.V}{v}, \frac{p.v}{V}, \frac{V}{p.v}\right]$

(6) Surface tension......with increase of temp.
[increases, decreases]

(7) Surface tension.........when an electric current is passed through the liquid. [increases, decreases]

(8) Surface tension......on the nature of the medium in contact with the liquid. [depends, does not depend]

III. Select the correct completion for each of the following statements :

(1) In the case of a metal wire, the elastic limit is reached when

(*a*) the load is more than the weight of the wire.

(*b*) the wire just breaks.

(*c*) on unloading, the wire is just able to regain its original size.

(*d*) elongation is inversely proportional to the tension.

(2) Steel is more elastic than rubber because for a given applied stress the strain produced in steel is

(*a*) greater than that in the rubber.

(*b*) less than that in the rubber.

(*c*) equal to that in the rubber.

(3) In absolute C.G.S. units, the stress should be expressed in

(*a*) dynes/sq. cm. (*b*) gm. wt./sq. cm.

(*c*) kg./sq. cm. (*d*) gm./sq. cm.

(4) What among the following is not defined as force exerted upon a unit area ?

(*a*) Stress, (*b*) Strain, (*c*) Pressure,

(*d*) Young's modulus.

(5) Suppose the elongation produced in a wire is twice its original length, then the Young's modulus is

(*a*) equal to the stress. (*b*) twice the stress.
(*c*) one half of the stress. (*d*) none of these.

(6) A mass is suspended from a spiral spring at rest. If this mass is pulled down, the potential energy stored in the system

(*a*) has increased. (*b*) has decreased.
(*c*) remains constant.

(7) A mass M is suspended from a spiral spring*. The spring can be made to vibrate if M is released after pulling it down. Its time period is proportional to

(*a*) M^2, (*b*) M, (*c*) $\sqrt{M}$, (*d*) $1/M$.

(8) The volume of liquid flowing per second out of an orifice at the bottom of a tank does not depend upon

(*a*) the area of the orifice.
(*b*) the height of the liquid above the orifice.
(*c*) the density of the liquid.
(*d*) the value of the acceleration due to gravity.

(9) An aeroplane is made streamlined to

(*a*) increase the air resistance ;
(*b*) decrease the air resistance ; (*c*) none of the above.

(10) The underside of an aeroplane is made

(*a*) concave ; (*b*) convex ; (*c*) plane.

(11) When a liquid flows through a pipe of variable bore, the pressure is

(*a*) highest where velocity is also highest ;
(*b*) lowest where velocity is also lowest ;
(*c*) highest where velocity is lowest ;
(*d*) none of the above.

(12) Water is flowing through a pipe of uniform cross-section under constant pressure. At some place, the pipe becomes narrow. The speed of water at this place

(*a*) decreases ; (*b*) increases ;
(*c*) remains the same ; (*d*) depends upon several factors.

IV. Suggest a suitable scientific term for each of the following statements :

(1) Behaviour of bodies even within the elastic limit requiring some time to regain their original shape and size after the deforming force has been removed.

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*Stiffer the spring, shorter will be its time period.

(2) A stage where a wire appears to flow beyond the elastic limit.

(3) A stage when a body is permanently strained and does not regain its original condition after removing the deforming force stretching beyond the elastic limit.

(4) The breaking stress for a wire of unit cross section.

(5) An inherent property of all liquids by virtue of which retarding forces are called into play when a fluid begins to flow.

(6) A motion in which the velocity of flow is not large so that the various layers of a fluid continue to move along parallel paths.

(7) A motion in which the velocity is large so that the various layers of a fluid move along zig-zag paths.

(8) The sum total energy is not changed during the displacement of a fluid.

CHAPTER XII

PASCAL'S LAW AND ARCHIMEDES' PRINCIPLE

I. Complete the following statements with suitable word or words :

(1) The thrust per unit area is called......

(2) The pressure of a liquid at rest depends upon......but not on the......of the liquid.

(3) The thrust of a liquid at rest is always......to the surface in cantact.

(4) The pressure of a liquid is...... in all directions at the same level.

(5) $P = \ldots\ldots \times d \times \ldots\ldots$

(6) A well in which water is forced upwards by the pressure of water from higher levels is known as ......well.

(7) Buoyancy is due to......of liquids.

(8) A balloon rises in air because......

(9) Pascal's law is also known as......

(10) Mechanical advantage of a Bramah's Press

$$= \frac{\text{area of press plunger}}{\ldots\ldots\ldots\ldots} = \frac{(\text{radius of press plunger})^2}{\ldots\ldots\ \ldots}$$

(11) The phenomenon of balancing or lifting a man with the help of a few grams of liquid is known as......

(12) A sinking ship will......the bottom of the sea.

(13) A floating body is said to be in stable equilibrium when its meta centre is......the C.G. of the body.

II. Select one from several alternatives given within the brackets to fill up the following :

(1) Ice is......than water. [lighter, heavier]

(2) Cream is......than milk. [lighter, heavier]

(3) A ship on passing from fresh water into sea-water...... [rises higher, sinks lower, its position remains unaffected]

(4) A body weighs......in vacuum than in air. [more, less, same]

(5) A hydrometer will sink more in a...... liquid. [denser, lighter]

(6) For greater sensitiveness, we have to use a hydrometer with a......stem. [thin, thick]

(7) For a more accurate result, we will prefer a hydrometer with a......volume. [small, large]

(8) When the weight of liquid displaced by a body is more than its wt., the body will...... [sink, float]

(9) Thrust on the base of a vessel containing a liquid......equal to the weight of the liquid contained. [need not be, must be]

(10) In a liquid under the action of gravity, the average intensity of pressure over a given plane area......equal to the intensity of pressure at the C.G. of the area. [is not, is]

III. Choose the correct completion for each of the following statements :

(1) Bramah press is a device used for

(*a*) pressing clothes ; (*b*) pressing bales of cotton ;
(*c*) printing books.

(2) Water stored in a dam exerts pressure in

(*a*) all directions ; (*b*) upward direction only ;
(*c*) downward direction only ; (*d*) sideways only.

(3) A body is weighed in air and then weighed in water. Its weight in water

(*a*) will be more ; (*b*) will remain same ; (*c*) will be less.

(4) When a piece of ice floating on the surface of water in a beaker melts completely, the level of water

(*a*) rises ; (*b*) falls ; (*c*) remains same.

(5) A dish of light material, partially filled with water, is floating in a pan of water. A small stone, tied to a string, is carefully lowered into the water in the dish such that it does not touch the sides of the bottom of the dish. We observe that

(*a*) the dish maintains its level in the pan.
(*b*) the level of the dish sinks a little lower.
(*c*) the level of the dish rises a little higher.

(6) A balloon filled with air is lowered to the same depth, first in river water and then in sea-water. In sea-water it will shrink

(*a*) more than that in river water.
(*b*) less than that in river water.
(*c*) to the same extent as in river water.

IV. State which of the following statements are true or false :

(1) Pressure of a liquid does not depend upon the base area of the container.

(2) Thrust on the base of a vessel containing a liquid need not be equal to the weight of the liquid contained.

(3) A thin and short column of water can support the weight of a man.

(4) The buoyancy will be same for a wooden block and an iron block of the same size, pushed under the surface of water.

(5) 1 kg. of compressed cotton weighs more than 1 kg. of loose cotton.

(6) A man once tried to find the density of air by weighing a small rubber balloon empty, and weighing it again after blowing in some air. He found no difference between the two weighings.

(7) It is easier to swim in fresh water than in sea-water.

CHAPTER XIII

ATMOSPHERIC PRESSURE AND ITS APPLICATIONS

I. Complete the following statements with suitable word or words :

(1) Barometer is the instrument used for measuring .....pressure.

(2) In......Barometer, no liquid is used.

(3) Normal Atmospheric Pressure is equal to......

(4) Ink leaks out of a partially filled pen when taken to a higher place because the pressure inside the pen is......than that outside

(5) The barometer used to measure height is called......

(6) The space above mercury in a barometric tube is called.....

(7) If an air-bubble is introduced into the bottom of a barometer, it steadily......in size, as it rises through the mercury.

(8) Perfect gases obey Boyle's law at......

(9) A valve allows a liquid or a gas to flow in......direction only.

(10) A manometer is used for......

(11) An air pump cannot produce a......vacuum.

II. Fill in the blanks, using correct words from those given in the brackets :

(1) While the valves of an exhaust pump open......those of a compression pump open...... [inwards, outwards]

(2) The......arm of the siphon tube should be placed in the vessel cotaining a liquid. [longer, shorter]

(3) Water......be siphoned over a mountain. [can, cannot]

(4) A falling barometer indicates the approach of...... [fair weather, storm, rain]

(5) Diameter of the barometer tube......the readings. [affects, does not affect]

(6) The reading is......if the barometer tube is inclined to the vertical. [affected, not affected]

(7) A barometer will read......in a building than in the open owing to the roof. [lower, higher, same]

(8) An aneroid barometer which is used as an altimeter becomes...... sensitive with increasing height. [less, more, same]

(9) A water pump will raise water to a greater height at...... [Dehra Dun, Delhi]

(10) The best portable type of barometer is......barometer. [Aneroid, Siphon, Fortin's]

III. Select the correct completion for each statement :

(1) The atmosphere is held to the earth by
(*a*) winds. (*b*) clouds. (*c*) gravity.
(*d*) the rotation of the earth.

(2) Aneroid barometer is so called because
(*a*) it was invented by a scientist named Aneroid.
(*b*) the place where it was made is called Aneroid.
(*c*) it contains a special liquid called Aneroid.
(*d*) it does not contain any liquid.

(3) Siphon is used to
(*a*) take water from one place to another.
(*b*) empty heavy vessels without tilting.
(*c*) take liquid from lower level to higher level.

(4) Space above mercury in a Fortin's barometer contains
(*a*) air ; (*b*) water vapour ; (*c*) mercury vapour ;
(*d*) vacuum.

(5) A hole is bored at the top of a barometric tube. The level of mercury in the tube will
(*a*) rise ; (*b*) fall ; (*c*) remain stationary.

(6) Some water is introduced in a barometric tube. The level of mercury in the tube will
(*a*) rise ; (*b*) fall ; (*c*) remain stationary.

(7) In a Fortin's barometer
(*a*) water ls used ; (*b*) mercury is used ;
(*c*) no liquid is used.

(8) One 'bar' denotes a pressure equal to
(*a*) 1000 dynes/cm^2 ; (*b*) 10000 dynes/cm^2 ;
(*c*) 10^6 dynes/cm^2.

(9) In a water pump, water can be raised upto a maximum height of
(*a*) 15 metres ; (*b*) 5 metres ; (*c*) 10 metres.

(10) With increase in height above the ground, the atmospheric pressure
(*a*) increases ; (*b*) decreases ; (*c*) remains constant.

(11) A sudden decrease in the barometer reading indicates
(*a*) fine weather ; (*b*) approach of rain ;
(*c*) approach of strom or cyclone.

IV. State which of the following statements are right or wrong :

(1) A water pump can raise water through a height of more than 10 metres at Delhi.

(2) The liquid does not run out of an eye-dropper unless the rubber bulb is pressed.

(3) A siphon does not work in perfect vacuum.

(4) The production of perfect vacuum is possible with an air pump.

(5) Air has weight.

(6) The barometric height will change if the tube is tilted.

(7) The height of a building could be measured by means of an aneroid barometer.

(8) A mercury barometer could work horizontally in a satellite.

(9) The damaging effect of a tornado is chiefly due to a close existence of very high and very low pressures.

V. Match the statements of column A with those in column B :

Column A	*Column B*
(1) to lift water to any height.	(*a*) Altimeter is used
(2) for measuring height of mountains.	(*b*) Compression pump is used
(3) for forcasting of weather.	(*c*) Force pump is used
(4) for compressing air.	(*d*) Barometer is used
(5) to measure low pressure.	(*e*) Rotary oil pump is used
(6) to produce vacuum of high degree.	(*f*) Mc-Leod gauge is used

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CHAPTER XIV

MISCELLANEOUS

Remember the answers for the following types of questions also :

1. *What do the symbols stand for in the following formulae or relations ?*

$$F=\frac{m(v-u)}{t};\quad v^2-u^2=2a.s\ ;\quad \text{etc.}$$

Ans. Here, F stands for the force acting on a body of mass m for time t seconds, whose initial and final velocities are u and v respectively.

In the second case, v and u represent the final and initial velocities of a body which will travel a distance s with an acceleration of a.

2. *Write down the formulae for the measurement of the following quantities :*

Work done ; Potential Energy ; Kinetic Energy ; etc.

Ans. Here, Work done $W=\text{Force}\times\text{distance}=F\times s$

Potential Energy=Mass × gravitational acc. × height

$$=m.g.h$$

Kinetic Energy$=\frac{1}{2}m.v^2$

3. *How are the following quantities related to one another ? Write down the necessary formula also.*

(*i*) *Mass and velocity* ; (*ii*) *Time, distance and velocity* : *etc.*

Ans. (*i*) Momentum$=m\times v$

(*ii*) Distance travelled $s=ut+\frac{1}{2}at^2$

4. *Name the law which reads as follows* :

"Everybody, in this universe, attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them (*i.e.* their C.G.)."

Ans. It is called Newton's Law of Gravitation.

5 *Name the scientists with whom the following laws or statements are associated* :

(*i*) $Pressure \propto \frac{1}{Volume}$; (*ii*) $F=G.\ \frac{M.m}{d^2}$;

(*iii*) $Y=\frac{stress}{strain}=\frac{F.L}{a.l}$

Ans. (*i*) Robert Boyle (Boyle's Law).

(*ii*) Newton (Gravitation).

(*iii*) Young (Modulus of Elasticity).

6. *State the law or laws associated with the following scientists* [*e.g. in Mechanics*] :

(*a*) *Archimedes* ; (*b*) *Newton.*

Ans. (*a*) *Archimedes' Principle* : Whenever a body is immersed in a fluid, it loses its weight, the loss in weight being equal to the weight of the fluid displaced by its immersed part.

(*b*) *Law of Gravitation* (*see* Q. 4 above).

Short-Answer Questions

1. *Why is C.G.S. system more convenient than F.P.S. system?*

Ans. (*i*) The multiples or sub-multiples of the units of length and mass in the C.G.S. system can be quickly obtained just *by shifting the decimal point* towards right or left, while in the F.P.S. system long and different divisions and multiplications are required for this purpose.

(*ii*) In the C.G.S. system, *density and specific gravity* of a substance are given by the same number, while in the F.P.S. system the density of a substance is to be divided by 62·5 to get its specific gravity.

(*iii*) In the C.G.S. system, the *relation between mass and volume* of water is very simple, *i.e.* 1 c.c. of water weighs 1 gm. Thus knowing the mass of water in gm., we can at once know its volume in c.c. and vice versa.

2. *Why are the units under M.K.S. system used in engineering?*

Ans. Under this system we are saved from the trouble of applying higher multiples of 10 with the units of C.G.S. system. For example, erg is the absolute unit of work in C.G.S. system where 1 gm. cm. = 980 ergs is the practical unit. But engineers use joule as a unit of work, where one joule = 10^7 ergs.

3. *What is S.I. system of units?*

Ans. S.I. means *International System* of units. It is a combination of M.K.S. units in dynamics and M.K.S.A. units in electricity and magnetism.

In this system, primary units are those of length (metre), mass (kg.), time (sec), current (ampere), temp. (°C) and luminous intensity (candela).

4. *What are the main uses of dimensional equations?*

Ans. (*i*) To test the correctness of equations.

(*ii*) To derive physical equations.

(*iii*) To convert one system of units into another.

(*iv*) To recapitulate important formulae.

5. *What do you mean by "Back-lash Error" of a screw and how can it be removed?*

Ans. On account of wear and tear between the screw and its nut, or due to bad-fitting, generally there is some place for the play of the screw, so that when the screw is adjusted by rotating it in one direction and is then rotated back, the screw does not cover any linear distance for some rotation of the screw head. This error is called back-lash error.

This error can be considerably reduced by rotating the screw always in the same direction when the final adjustment is being made.

6. *Why is a screw gauge so called ?*

Ans. To gauge means to measure. The screw is used in this instrument. The diameters of wires are measured with the help of a screw gauge and the wires are given standard numbers. The process is called 'gauging' and hence the name of the instrument.

7. *How can you increase the accuracy of a spherometer* ?*

Ans. Accuracy of a spherometer can be increased by reducing its least count for which

(*i*) *pitch should be small*—we should take a finer screw ;

(*ii*) there should be *a larger number of divisions* on the circular scale, which needs a larger circular disc. [If this is done, the distance between the legs of the instrument will have to be kept large. This will render the instrument unsuitable for smaller surfaces.]

8. *What are the formulae for calculating R with the help of a spherometer ? And which one will you prefer to use ?*

Ans. There are two formulae :

$$R=\frac{l^2}{6h}+\frac{h}{2}\ ; \qquad \text{and} \qquad R=\frac{x^2}{2h}+\frac{h}{2}$$

where l=the distance between any two outer legs of the instrument, x=the distance of the screw from any outer leg and h=height of the surface travelled by the screw.

The first formula should be used because $l>x$ and hence % error in measuring l will be less and so the result will be more accurate.

9. *Can a body be called to be at rest and in motion at the same time ?*

Ans. *Yes.* A body can be at rest as well as in motion at the same time. All rest and motion are relative. A man sitting in a moving train is at rest with respect to other passengers sitting in the train but he is moving with respect to the trees standing near the track. Similarly, a house or a tower is at rest only with respect to an observer on the earth but to an astronaut it appears to be moving with the speed of the earth.

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* A spherometer has three legs because any three points determine a plane. Moreover for stable equilibrium, three is the minimum number of legs.

10. *An object is covering distances in direct proportion to the square of time elapsed. What conclusion can be drawn about its acceleration ?*

Ans. If s be the distance covered by a body and t the time elapsed, then

$$s \propto t^2 \qquad \text{(given)}$$

or $\quad s=k.t^2 \quad$ where k is a constant

Also $\quad s=\frac{1}{2}\,a.t^2 \quad$ where a is uniform acceleration

$\therefore \quad \frac{1}{2}\,a=k=$ a constant

Since $\frac{1}{2}$ is always constant, therefore a the acceleration must also be *constant.*

11. *A man holds one end of a plank, while the other end rests on a drum. The plank is horizontal. Then the man moves the plank forward, making the drum roll without slipping along a horizontal plane ; no slipping takes place either between plank and drum. How far must the man move before reaching the drum, if the plank is of length "l" ?*

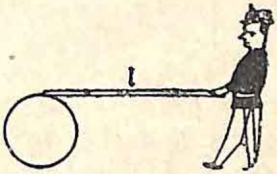

Fig. 1-23

Ans. When a drum rolls without slipping along a horizontal plane, the line with which it makes contact with the plane at any given moment is at rest and the drum itself is rotating about this line. Clearly, the line of contact with the plank is moving forward at a speed twice as great as that of the axis of the drum (Fig. 1-23). Therefore, when a man pushes the plank and moves forward a distance equal to the length of the plank the drum will move forward a distance equal to half the length of the plank. Thus the man must move a distance '2*l*' in order to reach the drum.

12. *Does the top of a wheel move faster than its bottom ?*

Ans. *Yes.* Every point on the wheel makes *two motions* simultaneously—one about the axis and the other forward together with the axle. *At the top,* the wheel's motion of rotation is *added** to its motion of translation (since both are in the same direction). At the *bottom,* rotation is made in the *reverse* direction and consequently must be *subtracted* from translation.

13. *How is it that on the dark side we move around the sun faster than on the sunlit side ?*

Ans. At *midnight* the speed of rotation is *added* to that of the earth's translation while at noon it is subtracted from the latter. As a result, at midnight we move faster in the solar system than at noon.

---

*A bottte thrown from a moving bus forwards (addition of two velocities and hence greater momentum) stands more chance of crashing when it hits the ground than if thrown backwards (subtraction of two velocities and hence less momentum).

[**Note** : Since any point on the equator travels about 0·5 km./sec, the difference there between midnight and midday speeds comes to 1 km./sec.]

14. *A man is walking in a vertical shower of rainfall. How should he keep his umbrella to protect himself from the rain ?*

Ans. In Fig. (1-24), rain is falling vertically downward along BOE while the man is travelling along OA direction. Since the man thinks that his velocity has nothing to do with the direction and velocity of the rain, therefore to bring him to rest, impress upon both the man and the rain a velocity OC equal and opposite to that of the man. Using parallelogram law of velocities, find the resultant of BO and OC velocities. This resultant R along OD is given by the parallelogram $OCDE$. Thus R is the *relative velocity* of the rain w.r.t. the man. And the umbrella should be kept so as to receive the rain along OD direction.

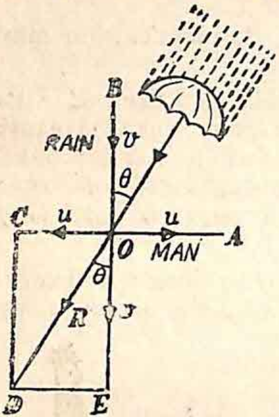

Fig. 1-24

[**Note** that $R > v$. This result has been used in Q. 15].

15. *A bucket is left out in the rain. Will the speed at which the bucket is filled with water be altered if wind starts blowing ?*

Ans. The speed of filling (*i.e.* the amount of water which falls into the bucket during unit time) *will not change.* Although the area of the cross-section of rain falling into the bucket decreases ($s_1 = s . \cos\theta$), the velocity of the drops not only changes direction (Fig. 1-25) but also increases in magnitude ($v_1 = v/\cos\theta$). Thus we get

$$v . s = v_1 . s_1$$

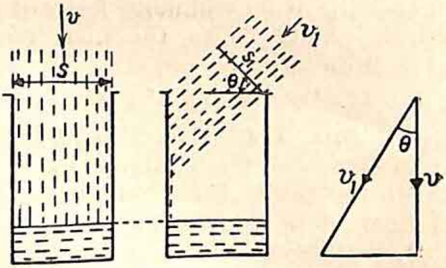

Fig. 1-25

In other words, the speed at which the bucket fills up depends only on the vertical velocity of the drops, which is not altered by the wind.

16. *A bomber, flying horizontally with a uniform velocity, releases a bomb much earlier than its position vertically above the target. Why is it so ?*

Ans. When the bomb is released, it continues to move in the horizontal direction. But at the same time, the force of gravity also attracts it vertically downward (with initial velocity zero). Thus the bomb has to follow the path which is the resultant of the horizontal uniform velocity and the vertically downward uniform acceleration acting simultaneously on the bomb. This trajectory is a *parabola*.

17. *A bullet is dropped from the same height and at exactly the same time another bullet is fired horizontally. Which one will hit the ground earlier?*

Ans. Both the bullets will hit the ground *at the same time*. Since the two velocities possessed by the bullets are independent of each other, each bullet continues to move without any interference from the other. Although the path taken by the second bullet (as a resultant of horizontal uniform velocity and vertically downward uniform acceleration) is a parabola yet (starting its downward journey with initial velocity zero) the time taken by it to reach the ground will be the same as that of the first bullet.

18. *A hunter aims his gun and fires a bullet directly at a monkey sitting in a distant tree. At the instant the bullet leaves the barrel, the monkey drops. Will the bullet hit the monkey?*

Ans. *Yes*; the bullet will hit the monkey.

The reason is that the horizontally fired bullet will go along a parabolic path as a resultant of horizontal uniform velocity and vertically downward uniform acceleration. Since the bullet also starts its downward journey with zero initial velocity, the same being the case with the falling monkey, both take the same time to fall through the vertical height of the tree. As both the monkey and the bullet reach the ground simultaneously, *the bullet will hit the monkey*, provided that the monkey is within the bullet's range.

[**Note** : If the monkey stays at its position, a horizontally fired bullet will never hit the monkey, since the bullet from the very beginning starts going downwards along a parabolic path. Therefore, we should aim at a point higher than the target to achieve success.]

19. *Why are the passengers jerked forward when a bus stops and fall backward when it starts?*

Ans. This is based upon *Newton's first law of motion*.

In the first case, both the bus and the passengers are in the state of motion. When the bus stops, lower portion of the passengers' bodies also comes to the state of rest while the upper portion *continues to be in the state of motion in a st. line*. Hence a forward jerk.

In the second case, the passengers are initially in the state of rest along with the bus. When the bus starts, along with it the lower portion of the passengers' bodies also starts moving forward while the upper portion of their bodies *continues to be in the state of rest*. Hence the passengers fall backward.

[**Note** : Similarly we can answer the following :

(*i*) *Why does a rider fall forward when a horse at full gallop suddenly stops* ?

(*ii*) *Why does a rider fall backward when a horse suddenly starts running* ?

(*iii*) *Why does a passenger fall down when he gets down from a moving bus*—unless he runs some distance in the direction of motion of the bus ?

(*iv*) All passengers in aeroplanes have to fasten their safety belts at take-off and when landing. Some aircraft engineers think that *all passenger-seats should face backwards,* then many injuries during crashes would be prevented.

(*v*) The **circus rider** travels as fast as the horse, even though he has jumped in the air. If he wants to land on the horse's back, he must jump *upwards*. If he jumps forward, he will find himself sitting on the horse's nose.]

20. *Why does dust come out of a hanging carpet by beating it with a stick* ?

Ans. This is on account of *Newton's first law of motion.*

At first, the dust and the carpet are in the state of rest. When the carpet is beaten with a stick, it moves forward while the dust is left behind as it *continues to be in its state of rest*. Consequently the dust comes out and falls down.

[**Note** : Similarly answer the question—'*On shaking a tree, why do fruits fall down* ? The tension in the supporting twig increases in its inclined position, due to which the twig breaks.]

21. *Who would win if there were a 10-metre race between a man, a horse and a car* ?

Ans. Such a race would be won by a man. Since the horse and the car are much heavier, it takes them a long time to pull away from rest.

22. *How can you find out whether an agg is boiled or not, without breaking the shell* ?

Ans. (**i**) : Place it on a flat smooth surface and twirl it. A hard-boiled egg will revolve much faster and longer than a raw one.

A hard-boiled egg revolves as one whole but the liquid contents of a raw egg do not have the motion of rotation handed over at once and so act as a brake—retarding by force of inertia the spinning of the solid shell.

Ans. (**ii**) : When we touch a twirling boiled egg with a finger, it stops at once. But a raw egg will resume spinning after we remove our finger since its liquid contents will still continue moving after the solid shell is brought to rest.

23. *Why does a cricket-fielder, while taking a catch, give a backward jerk to his hands ?*

Ans. This is based on the idea of *impulse.*

The change of momentum* of a body is equal to the product of the applied force (F) and the time (t) taken for the required change. Therefore for a given or constant change of momentum (of a moving cricket-ball which is to be brought to rest by the fielder) we find that F and t are inversely proportional to each other. By giving a backward jerk to his hands while taking a catch the fielder *increases the time* and thereby *decreases the applied force* with which the fast moving ball will strike his hands.

[**Note** : For the same reason, carriages are fitted with springs to reduce the severity of jerks.]

24. *A man is at rest in the middle of a pond on perfectly frictionless ice. How can he get himself to the shore ?*

Ans. The man should take the *help of Newton's third law of motion.* He has to create some kind of action in order to get an equal and opposite reaction. This he can do either by puffing violently or by throwing with a great force some of the articles (*e.g.* shoes, clothes, hat, etc.) available on his person. Thus, once he is in motion on the surface of ice, he will not stop till he reaches the shore because the ice is perfectly frictionless.

25. *Can a person raise himself by pulling at his own bootstraps ? Explain.*

Ans. *No.* The person and his boots form one system. If he pulls the boots (with the help of straps) upwards with a certain force of action, an equal and opposite force of reaction (along the straps) comes into play in accordance with Newton's *third law of motion.* These forces cancel each other and do not affect the initial position of rest of the person and his boots.

26. (*a*) *Can a man, seated in a chair, raise himself by lifting its arms ?*

(*b*) *Some persons sitting in a carriage at rest push it from within. Will the carriage move ?*

Ans. Same as under Q. 25 above.

27. *Why does a rocket go up ?*

Ans. Here, *Newton's third law of motion* is made applicable. When the fuel is ignited, a high-pressure gas is produced. This gas escapes downward with a very great force, giving rise to an equal and opposite force of reaction upwards. Consequently, the rocket shoots up with a great velocity.

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*You can move a brick placed on a smooth floor easily by pushing it with you foot Yet you will hurt your foot if you kick the brick.

[**Note** : Questions on the working of *jet-planes* and *fire-works* can be likewise answered.]

28. *When a man steps out of a boat, the boat moves backwards. Why ?*

Ans. (**i**) : This is because the man, in order to step out of the boat, pushes the boat backwards with his foot while the boat pushes him forward with an equal and opposite reaction. Thus acceleration is produced in them in opposite directions and we notice the boat moving backwards. Newton's third law of motion applies here.

Ans. (**ii**) : This can also be answered with the help of *law of conservation of momentum*. As long as the man is in the boat, their total momentum is zero since both are at rest. When the man steps out of the boat, a certain momentum is produced in him in the forward direction. To keep the total final momentum same (*i.e.* zero), the boat has to move back with the same momentum.

[**Note** : Similarly answer the question – *Why does a gun recoil on firing* ?]

29. *Why does a fireman appear struggling very hard with the water-pipe ?*

Ans. (**i**) : Here we can apply Newton's third law of motion. When the water-jet rushes out of the water-pipe, an equal and opposite force of reaction pushes the water pipe backwards. Evidently, the fireman has to apply a large force on the pipe to keep it at its initial position.

Ans. (**ii**) : Here we can also apply the law of conservation of momentum. Since the water rushes out at a high velocity, it possesses a large momentum in the forward direction. To keep the final total momentum also zero (equal to the total initial momentum of water and pipe both at rest), the pipe gets kicks in the backward direction. Evidently, the fireman has to apply a great force in order to keep the pipe-mouth at the same place.

30. *If a gun of mass M fires horizontally a bullet of mass m, what is the ratio of the energy of recoil of the gun to the energy of the bullet ?*

Ans. Let the velocity of the bullet be v and that of recoil of the gun be V. Then by the law of conservation of momentum,

$$m.v = M.V \quad \text{or} \quad \frac{V}{v} = \frac{m}{M}$$

$$\text{Also} \frac{\text{K.E. of recoil of gun}}{\text{K.E. of bullet}} = \frac{\frac{1}{2}\,M.V^2}{\frac{1}{2}m.v^2} = \frac{M}{m} \times \frac{m^2}{M^2} = \frac{m}{M}$$

31. *Two balls of different masses have the same kinetic energy. Which ball (lighter or heavier) will possess greater momentum ?*

Ans. Let m and M be the masses and v and V be the velocities of the lighter ball and heavier ball respectively. Then their K.E. $= \frac{1}{2}\,m.v^2$ and $\frac{1}{2}\,M.V^2$ and momenta $= m.v$ and $M.V$.

$$\because \quad \tfrac{1}{2}\, m.v^2 = \tfrac{1}{2}\, M.V^2$$

$$\therefore \quad \frac{m}{M} = \frac{V^2}{v^2} \quad \text{or} \quad \frac{V}{v} = \sqrt{\frac{m}{M}}$$

Then $\dfrac{\text{momentum of lighter ball}}{\text{momentum of heavier ball}}$

$$= \frac{m.v}{M.V} = \frac{m}{M} \times \sqrt{\frac{M}{m}} = \sqrt{\frac{m}{M}} < 1$$

Hence the *heavier* ball will possess greater momentum.

32. *Out of electron, proton, helium nucleus and cricket ball having the same kinetic energy, which has the largest wave length ?*

Ans. Proceed as in the above question and prove that the lighter body will possess smaller momentum.

Here electron has the least mass and so smallest momentum. Using De Broglie's relation for a body in motion

$$\text{Wave length } \lambda = \frac{\text{Planck's Constant } h}{\text{momentum } p}$$

we find that the *electron* will have the largest wave length.

33. *A rope passes over a pulley which is suspended sufficiently high. Two monkeys of equal weight climb the rope from opposite ends, one of them climbing more quickly than the other, relative to the rope. Which of the monkeys will reach the top first ? (Assume that the pulley is weightless while the rope is weightless as well as inextensible).*

Ans. (**i**) : Since there are no external forces which could impart momentum to the monkeys, so the monkeys can impart to each other (through the rope) only equal momentum. Evidently, however quickly the monkeys move their paws up the rope, they will rise, relative to the ground, at equal rates, because they are of equal mass. And the rope will move over the pulley, to the side of the monkey which climbs faster, with a velocity which will make the rates at which the monkeys climb, relative to the ground, equal. Therefore, *both monkeys will reach the pulley at the same time* (Fig. 1-26).

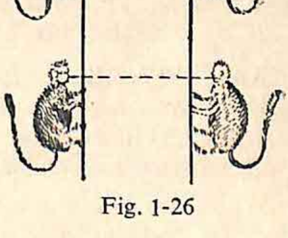

Fig. 1-26

[**Note** : Use the same reasoning, if the problem is posed with monkeys of different masses, *the lighter monkey will reach the pulley first.*]

Ans. (**ii**) : See answer to Q. 70 also.

34. *A bird is enclosed in a box standing on one pan of a pair of scales. While the bird is sitting on the bottom of the box, the scales are balanced by weights in the other scale-pan. What will happen to the scales if the bird takes off and hovers inside the box ?*

Ans. *Equilibrium will not be destroyed* if the bird takes off and hovers in the air inside the box. When the bird hovers, it must force the air downwords (action) in order to create an upward thrust (reaction) which can support it in air. The air thus forced downwards will create an additional pressure on the bottom of the box and the average magnitude of this pressure will be exactly equal to the bird's weight.

35. *A balance is mounted on a stationary trolley, with a weight suspended from one end, while the other end is linked to the floor of the trolley by a spring. If the trolley be accelerated in a horizontal direction by a constant force, the weight will be inclined at an angle in the direction opposite to the line of acceleration. Will this alter the tension of the spring ?*

Ans. In the inclined* position of the thread, it is subjected to an increased tension T' (Fig. 1-27). But the moment acting on the scale's beam is determined by the component of the force which acts perpendicularly to the arm. This force is the vertical component T of the thread's tension T', *which will be not changed* since the trolley's uniform aeceleration will produce a fixed inclination in the thread. Since the load, while inclining, remains stationary relative to the trolley (*i.e.* its acceleration in a vertical dirction equals zero), therefore the vertical component T of the thread's tension T' balances the weight W of the trolley. Thus the *tension in the spring will remain unaltered.*

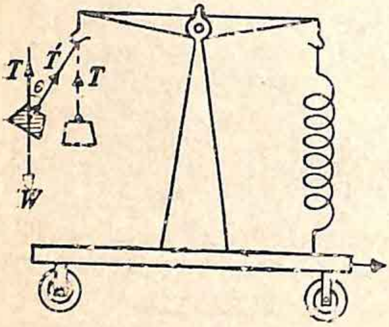

Fig. 1-27

36. *In a system consisting of one fixed and one movable pulley, the loads are in equilibrium when the ropes are parallel. What will happen if the point of attachment of the rope at A be moved to the right (Fig. 1-28)* ? Neglect the weight of the pulleys.

Ans. When the sections AB, CD and EF of the rope are parallel and the system is in equilibrium (Fig. 1-29), the tension T in the rope AB or CD must equal half the weight of load M_1. Thus the load M_2 must be half of load M_1.

When the rope's point of attachment A is shifted to the right to A', the sections $A'B'$ and $C'D$ of the rope are no longer parallel.

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*T is a component of T' and this component balances the weight W.

Evidently a decreased tension $T.\cos\theta$ in them would no longer be able to support the pulley from which M_1 hangs. Thus equilibrium is destroyed, the load M_1 descends and the load M_2 rises.

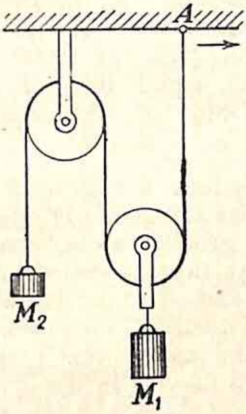


Fig. 1-28

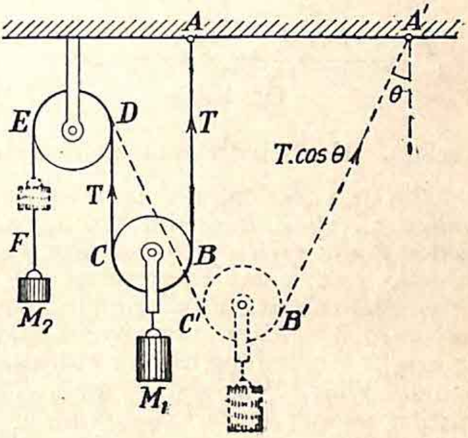


Fig. 1-29

37. *Two identical guns are mounted on a railway truck which is free to move along the rails, and point in opposite directions. The sites are set so that, if the guns are fired simultaueously, each will score a hit on its target. Will the shells still hit their targets if one of the guns fires slightly before the other ?*

Ans. Clearly *when both guns fire simultaneously*, the truck will remain stationary due to equal and opposite reactions. Under these conditions (firing from a stationary platform), the shells hit their targets. When *one of the guns fires sooner* than the other, then, in accordance with the law of conservation of momentum, the truck will begin to move in the opposite direction. Since the barrel of the gun also begins to move with the truck in the opposite direction, the shell will leave the barrel with a velocity (relative to the earth) which is reduced by comparison with its velocity when fired from a stationary platform. Therefore, *the shell will fall short of its target.*

The platform's motion continues right upto the *firing of the second gun.* Therefore, when it is fired, the second gun's barrel will be moving together with the truck, in the same direction as its shot. Thus the shell will have a slightly greater velocity when leaving the gun than if it had been fired from a stationary gun. Therefore, *it will overshoot its target.*

38. *In the face of Newton's third law of motion, why should a horse be able to move a cart ?*

Ans. The cart and the horse press the earth downward while the earth pushes each one of them up with an equal and opposite force, hence all the three (cart, horse and earth) remain at rest. The horse pulls the cart in the forward direction while the cart pulls the horse with an equal force T (Fig. 1-30) in the opposite direction. Hence both will remain at rest.

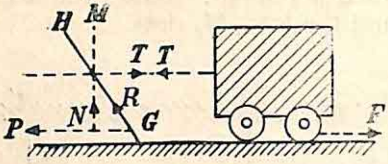


Fig. 1-30

To start motion, the horse presses against the ground in a *slanting* direction HG with his legs and gets an equal and opposite reaction R along GH. This reaction R of the ground can be resolved into two rectangular components : (*i*) the vertical component along NM which decreases the weight of the horse and (*ii*) the horizontal component P which tries to move the horse forward. This motion is opposed by the limiting friction F, between the cart-wheels and the ground. When P exceeds F, the horse starts moving in the forward direction, pulling the cart along with it.

39. *When will you weigh more—while bending or while straightening ?*

Ans. When you bend, the muscles that do this also pull up the lower half of your body and this diminishes the pressure exerted by your feet on the scales which will show less weight.

When you straighten up, your muscles push the upper and lower halves of the body away from each other. Here the scales will indicate a greater weight since the lower half of your body exerts a greater pressure on the scales.

[**Note** : You will increase your weight even by lifting an arm.]

40. *Why is it easier to pull than to push a lawn-roller ?*

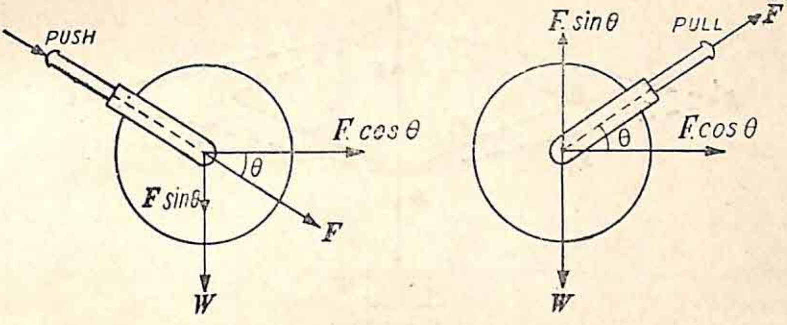
Ans. In Fig. 1-31, the circle represents the side-view of the lawn-roller whose weight W acts vertically downward.

When we push the roller (Fig. 1·31·*a*), let the applied force F make an angle θ with the horizontal direction. Then its vertically downward component F. sin θ increases the weight of the roller in which the horizontal component F. cos θ produces motion.

When we pull the roller (Fig. 1-31-*b*) with the same force F inclined at $\angle\theta$ with the horizontal, its vertically upward component F. sin θ decreases the weight of the roller in which the horizontal component F. cos θ produces motion.

Since, force = mass × acceleration, therefore, less acceleration is produced in pushing than in pulling. Hence, it is easier to pull than to push a lawn-roller.

[**Note** : Because the radius of a lawn-roller is less than our height upto our shoulders, that is why the applied forces (F, F) act along the directions shown in Fig. 1·31. *If the radius of a roller is greater than our height,* then pushing will be easier than pulling.]



(a) (b)

Fig. 1-31

41. *Why should we hang a heavy picture-frame by a longer thread ?*

Ans. In Fig. 1·32, a picture-frame of weight W is shown suspended vertically on a nail O with the help of a rope AOB. Since AOB is the same rope, tensions T_1 and T_2 will be equal. The frame is in equilibrium under the action of three forces W, T_1 and T_2. These can be represented both in magnitude and direction by the three sides of a $\triangle abc$, taken in order, on a convenient scale.

If the rope is now shortened, as shown by ANB, the triangle of forces now takes the form of $\triangle abc'$ where the weight W is still represented by the same line ab. Since on the same scale, $bc' > bc$, it follows that the tension T_1' in AN (=tension T_2' in BN) has increased from its former value T_1 or T_2. Evidently, *if the rope is shortened too much, it is more likely to break* under an increased tension. Hence to avoid this risk, we should use a longer rope.

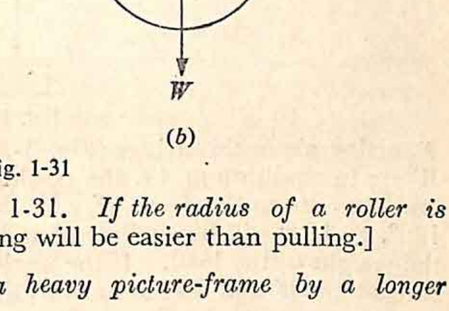


Fig. 1-32

42. *A load is attached to two strings AB and AC of equal length and suspended from them. In what case will the strings break most easily, when they hang down almost vertically or when they are stretched almost horizontally ?*

Ans. The strings will break more easily, the nearer they are to a *horizontal position*. To explain this, consider the tensions F_1 and F_2 acting along the strings (Fig. 1-33). These two forces and load W are in equilibrium, *i.e.* the resultant F of forces F_1 and F_2 is equal and opposite to the force W. If the angle between F_1 and F_2 is 120°, $\triangle ABD$ will be equilateral and the tension in each string equals the weight of the load. If the angle is less than 120°, each tension is less than W and decreases as F_1 and F_2 come closer to W's line of action. On the other hand, the nearer F_1 and F_2 move to the horizontal ($B'AC'$), the greater will be their value ($F_1'=F_2'$ drawn on the same scale for the load $W=F$). When the strings adopt an almost horizontal position, the tension in them is very great and they break easily.

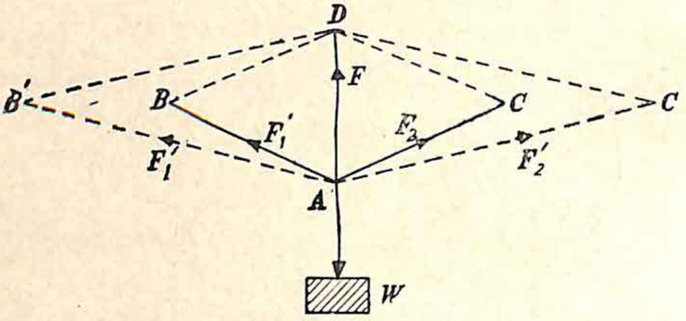


Fig. 1-33

42-A. (*a*) *Why is it so easy to break a tightly stretched string by pulling at it sideways ?*

(*b*) *Why must the cord supporting a tennis net be capable of withstanding a tension considerably greater than the weight of the net ?*

Ans. Same as for Q. 42 above.

43. *The following trick is sometimes used to move a car which is stuck : a rope is attached to the car and a tree, the rope being stretched as taut as possible. Then if a man pulls on the rope in a direction almost at right angles to it, he will easily move the car. Why is this possible ?*

Ans. Same as for Q. 42 above.

44. *A stone is whirled round on a string which suddenly breaks. Why should the stone fly off tangentially to its circular path if it was being acted upon by two equal and opposite forces, known as the centripetal and centrifugal forces ?*

Ans. Centrifugal force is a reaction of centripetal force. Though numerically equal, the two forces are not due to the same cause.

Centripetal force is exerted by the finger at the centre, on the revolving stone and is directed radially towards the centre. It is the tension in the string and is equal to mv^2/r.

Centrifugal force is due to the property of inertia of a body. The body is reluctant to move along a curved path and the centrifugal force is a measure of this reluctance. If the string be cut suddenly, the stone will fly outwards tangential to the circle because the centripetal force will disappear the moment the string is cut. Consequently, the reaction force, namely, the centrifugal force will also disappear. The stone continues its motion in a st. line due to its inertia.

45. *Why does not water fall out of a bucket revolving even in a vertical plane ?*

Ans. Water does not fall out of the bucket, swung round in a vertical plane, only when its *speed of rotation is sufficiently high.* When the bucket is upside-down, the centrifugal force ($=mv^2/r$) acting upward is greater than the weight ($=mg$) of the water acting downwards. Hence, the water cannot move out of the bucket.

46. *In a circus, a fast-moving motor-cyclist does not fall down even when he moves along the uppermost portion of the "well of death". Why ?*

Ans. Same as for Q. 45 above.

47. *Why does a cyclist lean inward when riding round a curve or a corner ?*

Ans. Here the cyclist does so in order to supply himself the centripetal force required to move him along a curve. The weight of the cycle and the cyclist acts vertically downward through C.G. of the system. When the cycle takes a slanting direction, an equal and opposite reaction is applied by the earth. The vertical component of this reaction balances the weight of the system while its horizontal component supplies the necessary centripetal force which enables the cycle to move in a circular path round a corner.

48. *How does a cream separator work ?*

Ans. The magnitude of the centrifugal force (mv^2/r) depends upon the mass (and hence the density) of the body—heavier the body, greater the contrifugal force. Cream is lighter than the skimmed milk. Therefore, the skimmed milk needs a greater force for revolving its particles in a circle. When the cream-separator, containing milk, is rotated at a high speed, the heavier particles of skimmed milk move outward (and collect near the walls of the vessel) on account of their greater centrifugal force while the lighter particles of cream stay near the centre of the vessel. Thus, cream is separated from milk.

49. *Why are curved tracks banked ?*

Ans. When a fast-moving railway train (or any vehicle) takes a curved path, it must be provided with sufficient centripetal force. This force is provided by the friction between the rim of the wheels and the rails. This abnormal friction causes extra wear of the tracks and wheels. To minimise this, the tracks are so laid that *the outer* *track of the bend is slightly higher than the inner.* This is called "banking of the rails or tracks". In the absence of banking, the vehicles may overturn or leave its track due to its centrifugal force.

[**Note** : The angle of banking* depends upon the *radius* of the curve and the *speed* of the vehicle but not upon its mass. The sharper the curve and greater the speed, the greater is the banking required.]

50. *Why is the earth gradually flattening at the poles and bulging at the equator ?*

Ans. Originally, the earth was a sphere of fused plastic matter. Due to its diurnal rotation about its axis, the centrifugal force (mv^2/r) produced by its rotation started acting on every particle (of mass m, say) of matter forming the earth (Fig. 1-34). Particles situated on the equator possess maximum velocity as they have to cover maximum distance in 24 hours taken by the earth to complete its one revolution. This velocity goes on decreasing as we go towards the pole and is zero at the poles. Since the changes in the value of $v^2[=(2\pi r)^2]$ are far greater than the corresponding change in the value of r, therefore for the particles situated on the equator the centrifugal force is maximum and decreases on going towards the poles. At the poles, this force is zero. Due to this constant force, even a body like the earth has to yield—as a result the earth bulges at the equator and is flattened at the poles since the volume of earth remains unaltered.

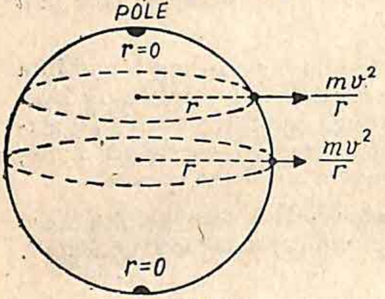


Fig. 1-34

51. *The driver of a car suddenly sees a broad wall in front of him. Is it better for him to apply brakes or to turn sharply ?*

Ans. Let m be the mass of the car, v its velocity and d its distance from the wall.

If the driver apples his brakes, the car will stop when its kinetic energy ($=\frac{1}{2}mv^2$) has been expended in work against the force of friction (say F). Let the car come to rest after covering a distance x. Then

$$\frac{m.v^2}{2}=F.x \qquad \text{or } x=\frac{m.v^2}{2F}$$

If the car is not to be smashed up, we must have

$$x=\frac{m.v^2}{2F}\leqslant d \text{ or } F\geqslant\frac{m.v^2}{2d} \qquad ..\ (i)$$

If the car is turned, the same force of friction will play the part of a centripetal force ($=mv^2/r$) which makes the car move along the arc of a circle of radius, say, r. Then

---

*An aeroplane must make a correct banking angle while making a curved flight.

$$F=\frac{m.v^2}{r} \quad \text{or } r=\frac{m.v^2}{F}$$

If the car is not to be smashed up, we must have

$$r=\frac{m.v^2}{F}\leqslant d \quad \text{or } F\geqslant\frac{m\,v^2}{d} \qquad \ldots(ii)$$

From Eqs. (*i*) and (*ii*), we notice that to avoid crashing into the wall, *braking requires half the force of friction which a turn requires.* So it is better to apply brakes rather than to turn.

52. *Every body falls to the ground when released from the hand. Are not smoke, steam and gas, which ascend, exceptions to this rule?*

Ans. They may appear so at first sight, but they rise in the air simply because they are lighter than the atmosphere surrounding them. That they have weight may be proved by introducing some smoke into a glass jar and then removing all the air therefrom. In the vacuum so formed, the smoke will be seen descending by its own weight.

[**Note**: A gas kept in a closed container diffuses and occupies all the available space. There is no container round the earth's atmosphere and yet the air in atmosphere stays due to gravity. If a molecule of air is hit by another molecule from below, it moves npwards but ultimately returns downwards due to gravity.]

53. *If gravitation is the power by which all bodies tend towards each other, then why do all bodies tend towards earth's centre?*

Ans. Gravitational force attracts bodies in proportion to masses. The earth, being so immensely large in comparison with all other bodies in its vicinity, destroys the minute effects of mutual attraction between smaller bodies, and thus brings them all to itself.

54. *What is the difference between the inertial mass and the gravitational mass of a body? How are they related?*

Ans. That mass of a bedy which measures its inertia and determines the external force required to move it along a horizontal frictional surface is called its **inertial mass**. The gravity does not enter into picture here. The force required to move the body will remain the same even if the gravity is altogether absent. The greater the mass of the body, the greater the force required to move it.

On the other hand, **gravitational mass** of the body is that which determines the gravitational pull (known as its weight) due to earth acting upon it. To hold the body at rest above the earth, an upward force equal to the weight of the body has to be applied on it. This weight is also proportional to the mass of the body. The inertia of the body does not play any role here.

These masses of a body are the same.

55. *Which raindrops fall faster, big ones or little ones? Why?*

Ans. Two forces act on a falling drop ; the force of gravity which is constant and which accelerates the drop's motion, and the resistance of the air which retards the drop's motion and which grows as the drop's velocity grows. The force of air-resistance grows until it is equal to the force of gravity. Then the drop's velocity ceases to alter and it continues to fall at a constant velocity called *terminal velocity.*

If the dimensions of the drop are increased, the force of gravity is increased in proportion to the drop's volume, *i.e.* in proportion to its (radius)^3, while the force of air- resistance increases in proportion to drop s cross-section, *i.e.* in proportion to its (radius)^2. Therefore, as the drop's radius increases, the force of gravity increases faster than the air-resistance. Evidently the constant speed at which the drop falls to earth also increases with the increase of the drop's dimensions.

Thus, a bigger raindrop falls faster.

56. *Two spheres of the same radius and the same material fall through the air from the same height. One sphere is solid, the other is hollow. Which sphere will fall faster ?*

Ans. Start with para 1 of Q. 55 given above.

Since the cross-section of both the spheres is same, they will both encounter the same air-resistance when travelling at the same velocity. But since the solid sphere is heavier than the hollow one, its resultant downward force ($=m.g-$air resistance) will be greater and hence its downward acceleration (given by $F=m.a$) will all the time be greater ; accordingly the solid sphere will fall faster.

57. *Why does an astronaut orbiting round the earth feel weightless ?*

Ans. The reason is that the force of gravity acting on the astronaut is used for providing the necessary centripetal force which keeps him moving in the orbit. Therefore, he feels weightless and thus he can comfortably walk or float in air.

58. *A space-ship carrying an astronaut was placed in orbit* by a powerful rocket. The carrier-rocket developed a thrust which accelerated the ship upwards. The rocket-fuel was used up soon after the ship was put in orbit. How did the weight of the astronaut change during the flight* (*i*) *before and* (*ii*) *after the rocket motor stopped working ?*

Ans. (**i**) *Before the rocket-motor stopped working*, the space-ship was moving upward with a constantly increasing acceleration on account of the upward thrust. At any instant, if this upward acceleration is a, then

$$\text{apparent wt. of the astronaut} = m(g+a)$$

which is greater than his real weight ($=m.g$). Thus the apparent wt. of the astronaut will *go on increasing.*

---

*A satellite going round the earth in a circular orbit does not cover any distance along the direction of the gravitational field and hence the work done by this field on the satellite is zero.

(ii) *After the rocket-motor stopped working*, the wt. of the astronaut becomes *zero* (*See* the reason in the answer of Q. 57 above).

59. *A man jumps off a table with a 5 kg. weight in his hand. What is the pressure of the weight on his hand while he is in air ?*

Ans. The pressure of the weight on his hand will be *zero* while he is in air.

Here the hand can be assumed to be working as a lift descending vertically downward with an acceleration, say a. Then the apparent weight of a body lying on it is given by

$$R=m(g-a)$$

Since the body of 5 kg. weight is descending with the same acceleration $a=g$ along with the hand,

$$\therefore \qquad R=m(g-g)=0$$

60. *Two holes are made in the side of a cylindrical bucket, symmetrically placed on opposite sides. The holes are closed with corks and the bucket is filled with water. If the corks be taken out, the water will stream out of the holes. What will happen if the bucket falls freely ?*

Ans. While the bucket is falling freely, the upper layers of water will cease to exert pressure on the lower layers and therefore there will be no pressure on the side-walls of the bucket. Thus *the water will cease to flow out of the holes.*

61. *The crewmen in a spaceship are discussing whether they could crack a walnut with a hammer. Man A says that hitting the walnut with the hammer would be no more effective than hitting it with a feather because the hammer is weightless out in space. B states that he found the mass of the hammer to be about 1 kg. by comparing it with known masses on an equal arm balance ; therefore, he would break the walnut as easily as back on earth. C maintains that the comparison with other masses proved nothing, because out in space they too are weightless ?*

Comment on the statements of the crewmen. Can they crack the walnut ?

Ans. The crewman C is correct because B could not have weighed the hammer in space as it would have balanced as well with a feather as with a standard kg. mass.

The crewman A is completely wrong while B is right in assuming that he can use the hammer to crack the walnut. The impact depends on the momentum ($=m\,v$ where *mass* obeys the law of conservation and is never zero) or on the mass of the hammer and not on its weight. Therefore, B will succeed in cracking the walnut out in space with the help of a weightless hammer also.

62. *The earth is acted upon by the gravitational attraction of the sun. Why does not the earth fall into the sun ?*

Ans. If the earth started from rest, it would fall on a st. line into the sun. But actually the earth is moving around the sun in a stable orbit with a constant speed. At any instant, the earth has to move simultaneously under the action of two velocities : (*i*) its own uniform velocity tangential to the orbit of its rotation, and (*ii*) accelerated velocity towards the sun due to sun's gravity. Consequently, the earth takes a parabolic path and thus it misses the sun as it falls towards the sun.

63. *What is a satellite ? Calculate the velocity of a projectile so that it becomes a satellite of the given planet.*

Ans. A heavenly body that revolves about a larger one is referred as a satellite. For example, the moon is the satellite of the earth.

A projectile can be thrown with such a velocity (called *orbital velocity*) that it starts revolving around the earth and does not fall down to the ground. Let G be the gravitational constant, M the mass of the earth (or the given planet), r the radius of the orbit on which the projectile is made to move, m the mass of the projectile and v_0 the orbital velocity of the projectile. Then equating the centrifugal force and the gravitational force at any point situated on the given orbit, we have

$$\frac{m.v_0^3}{r}=G\frac{M.m}{r^2}\,; \qquad \text{or} \qquad v_0=\sqrt{\frac{G.M}{r}}$$

64. *The distance of Neptune and Saturn from the Sun is nearly 10^{13} and 10^{12} metres respectively. Assuming that they move in circular orbits, find the ratio of their periodic times.*

Ans. If G be the Universal Gravitational Constant, M the mass of sun, and r the radius of the orbit on which a body is moving, then the orbital velocity of the moving body is

$$v_0=\sqrt{G.M/r}$$

Dividing the circumference of the orbit by the orbital velocity, we get the time periods t_1 and t_2 of Neptune and Saturn respectively as

$$t_1=\frac{2\pi r_1}{v_0'}=2\pi r_1\times\sqrt{\frac{r_1}{G.M}}\propto(r_1)^{3/2}$$

$$t_2=\frac{2\pi r_2}{v_0''}=2\pi r_2\times\sqrt{\frac{r_2}{G.M}}\propto(r_2)^{3/2}$$

$$\therefore \qquad \frac{t_1}{t_2}=\left(\frac{r_1}{r_2}\right)^{3/2}=\left(\frac{10^{13}}{10^{12}}\right)^{3/2}=(10)^{3/2}=10\sqrt{10}$$

[**Note :** If a satellite is positioned at a height of 37000 km., its time period of rotation around the earth will be roughly 24 hours and hence it will maintain the same position (*i.e.* will appear at rest) in relation to an observer on the earth.]

65. *What do you mean by the escape velocity of a projectile? Calculate its value in the case of earth.*

Ans. When from a planet a body is thrown with such a minimum velocity that it escapes into space and never returns to the planet, then this velocity is called the *escape velocity* of a projectile.

A body of mass m situated on the surface of the earth of mass M and radius R will experience a gravitational force $\Big\}=G\,\dfrac{M\,m}{R^2}$

If $m=1$, then intensity of gravitational field $=\dfrac{G.M}{R^2}$

Then the work done in moving a unit mass from infinity to the surface of earth *i.e.* gravitational potential* $\Big\}=\dfrac{G.M}{R}$

And the work done in moving a mass m from infinity to the surface of the earth$=\dfrac{G.M.m}{R}$ which must be equal to the inimum kinetic energy supplied to the body so that it escapes into space. If v_e be the escape velocity, then

$$\frac{1}{2}\,m.v_e^2=\frac{G.M.m}{R} \quad \text{or} \quad v_e=\sqrt{\frac{2\,G.M}{R}}$$

$$\text{For earth,}\quad v_e=\sqrt{\frac{2(6\cdot67\times10^{-8})(5\cdot98\times10^{27})}{6\cdot37\times10^{8}}}\ \text{cm./sec.}$$

$$=11\cdot2\ \text{km./sec.}$$

66. *What is the ratio of the K.E. required to be given to a satellite to escape earth's gravitational field to the K.E. required to be given so that the satellite moves in a circular orbit just above earth's atmosphere?*

Ans. As here the radius of the earth will be nearly equal to the radius of the orbit while calculating the orbital velocity, we get

$$\text{K.E. for orbital velocity}=\frac{1}{2}\,m.v_0^2=\frac{G.M.m}{2.r}$$

$$\text{K.E. for escape velocity}=\frac{1}{2}\,m.v_e^2=\frac{G.M.m}{r}$$

Thus escape K.E. is *twice* the orbital K.E.

67. *Will there be any change in the weight*† *of a body if the speed of the earth changes? Explain.*

Ans. *Yes*; there will be a change in the weight of a body if the speed of the earth changes.

---

*See Frictional Electricity chapter on Electrostatic Potential.

†The value of g will increase if the earth stops rotating.

The weight of a body is equal to the force of gravity ($=m.g$) with which a body is attracted by earth towards its centre. This force is opposed by the centrifugal force($=mv^2/r$) acting on the body and produced due to the diurnal rotation of the earth about its axis. Therefore, a part of the force of gravity is neutralised by the centrifugal force. Hence the weight of the body decreases if the centrifugal force increases or the speed of rotation of the earth increases and *vice versa.*

68. *Will the draught of a steamer be altered as a result of a change in the force of gravity's acceleration, if it changes latitude by sailing from northern to equatorial waters ?*

Ans. The change in the acceleration caused by the force of gravity which takes place on a change in latitude acts equally on the steamer and on water in which the steamer floats. Therefore, the steamer's draught *will not alter.*

69. *A rocket is out in free space, shooting out a stream of exhaust gases and picking up speed in the opposite direction. What happens to the centre of all the matter—that which is ejected and that which is left in the rocket ?*

Ans. A rocket (consisting of the ejected matter and that which is left in the rocket) moving in free space represents an isolated system and no external forces are acting on the rocket system. Therefore, according to Newton's second law of motion, the centre of mass (or C.G.) in the system cannot have any acceleration. Hence the velocity of the centre of mass is constant.

70. *A rope is passed over a pulley which is suspended sufficiently high. Two monkeys of equal weight climb the rope from opposite ends, one of them climbing more quickly than the other, relative to the rope. Which of the monkeys will reach the top first ? (Assume that the pulley is weightless while the rope is weightless as well as inextensible).*

Ans. Let us imagine that the monkeys are on an absolutely smooth horizontal surface and hold opposite ends of a rope. Because there are no external forces acting, the C G. of the two monkeys must remain stationary. Therefore they can only move equal distances towards this C.G., however fast either of them moves its paws along the rope. Thus, both the monkeys will reach the point lying at the centre of the original distace between them simultaneously.

71. *A fly is sitting at the bottom of a test tube. The test-tube falls freely, maintaining its vertical position. How will the duration of the test-tube's fall be affected if the fly, during the test-tube's fall, flies up from the bottom of the test-tube to the top ?*

Ans. As long as the fly continues to sit at the bottom of the test-tube, C.G. of the system remains at a fixed position. And therefore, the C.G. of the system will also move with the acceleration of free fall.

But when the fly flies upward from the bottom of the test-tube (Fig. 1-35), the C.G. of the system will start rising up, *i.e.* the bottom of the test-tube will be lowered somewhat relative to the C.G. of the whole system (test-tube-plus-fly). Thus the bottom of the test-tube will strike the ground sooner than if the fly were to remain motionless. In other words, the *length of the time of the fall is reduced.*

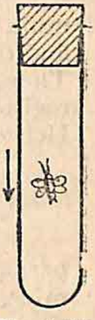


Fig. 1-35

72. *Why is a simple pendulum so called ?*

Ans. A simple pendulum is so called because :

(*i*) its motion is *simple* harmonic ;

(*ii*) everything about its construction, formula, position of C.G., *etc* is *simple* ;

(*iii*) it affords a very *simple* method of determining the value of g experimentally ;

(*iv*) it is much *simpler* in comparison to a compound pendulum.

73. *Why do we keep the amplitude of an oscillating pendulum small ?*

Ans. It is because the motion of a simple pendulum is simple harmonic only when amplitude is small. Also we have to assume in the derivation of the formula for the time period that $\sin\theta = \theta$ which holds good only when θ is small *i.e.* the amplitude is less.

74. *What will happen if the pendulum bob is replaced by a very light ball, e.g. a ping pong ball ?*

Ans. The bob should be heavy. If it is light, it will be disturbed even by a slight wind. The restoring force$=m.g. \sin\theta$ will by small now and in its comparison the resistance of air cannot be neglected.

75. *Why is the pendulum bob round only ?*

Ans. In this form, the effect due to resistance of air is minimum because for a given volume a sphere has least surface area.

[**Note :** See Ans. to Q. 79 also. Combine the two answers.[

76. *A pendulum clock was regulated to give correct time at Dehradun. When taken to Mussoorie, it was found to lose time. Why ?*

Ans. Since the pendulum clock was regulated at Dehradun, its time period $t=2$ seconds. But as we go from Dehradun to Mussoorie, we are moving away from the centre of the earth, the value of g decreases since $g \propto 1/(R+h)^2$ where R is the earth's radius at Dehradun and h is height of Mussoorie from Dehradun. Using the formula $t=2\pi\sqrt{l/g}$ for the time period of a simple pendulum, we shall find that t at Mussoorie will be greater than 2. Let it be 2·02 seconds. Then, though the actual time elapsed is 2·02 seconds, yet the clock registers 2 seconds due to its mechanism(1 sec. for each oscillation). Hence in each 2·02 seconds, the clock loses 2·02—2=0·02 second.

77. *A pendulum clock, regulated on the surface of earth, was taken into a deep mine. Will it gain or lose time? And why?*

Ans. On the surface of the earth (of radius$=R$), the time-period of the pendulum will be 2 seconds. If we go to a depth h in a mine, the distance from the centre of the earth remains $(R-h)$. Since the mass of that part of earth, which attracts the pendulum bob towards centre, also decreases, therefore it can be shown that $g\propto(R-h)$. In other words, as we go deeper and deeper inside the earth, the value of g also decreases. Using the formula $t=2\pi\sqrt{l/g}$, we find that the time-period t increases. Suppose it becomes 2·01 seconds though the clock registers only 2 seconds (1 sec. for each oscillation due to its mechanism). Hence the clock *loses time*=0·01 second in every 2·01 seconds.

78. *Upon what factors does the value of 'g' depend?*

Ans. (*i*) *Latitude* : Its value is greatest at the poles and least at the equator.

(*ii*) *Altitude* (*i.e.* distance from the centre of earth) : Its value is less at the hills than at the plains.

(*iii*) *Depth* : It decreases as we go down in a mine.

(*iv*) *Rotation of the earth about its axis* : Due to centrifugal force, the bodies on the equator tend to fly away and hence the value of 'g' is less.

79. *Why do we take a spherical bob in a simple pendulum? Can we take a hollow bob?*

Ans. We use a spherical bob because its mass is uniformly distributed and its C.G. is at its centre. Moreover this helps us in finding the effective length of the pendulum easily by finding its diameter with a vernier callipers.

We can use a uniform hollow bob since its C.G. will also be at its centre.

[**Note** : A hollow sphere containing mercury is the bob of a simple pendulum. If a little mercury is drained off, the C.G. of bob goes down, the effective length of pendulum is increased and so its time period will increase]

80. *What will happen if a simple pendulum bob is made to oscillate in (a) water, (b) vacuum?*

Ans. (**a**) In water, the time period will increase because due to the upthrust of water, the effective pull of the earth on the bob will decrease.

(**b**) In vacuum, the effect of buoyancy of air will disappear and hence the value of 'g' will slightly increase, resulting in the slight decrease of the time period.

81. *An old clock loses a minute a day. Is the pendulum too short or too long ? And why ?*

Ans. The pendulum is *too long*. Since the length (l) of the pendulum appears in the numerator of the formula for its time-period $t=2\pi\sqrt{l/g}$, therefore, longer the pendulum, the longer it will take to complete one vibration and hence will lose time.

82. *What is the use of pendulum in an ordinary clock ?*

Ans. Firstly, the pendulum helps in keeping regular intervals of time in the clock by its regular and steady motion. Secondly, by its regular swing, it controls the rotation of the toothed wheel of the clock and so keeps correct time.

83. *A heavy pendulum bob is suspended from the roof of a stationary car. How will its direction be affected when (i) the car starts, (ii) the car is travelling with a constant velocity, (iii) the car comes to a sudden stop ?*

Ans. (**i**) When the car starts, its roof will also begin to move in the same direction and along with it the upper end of the pendulum. But the pendulum bob will not have received the motion of the car and hence it will be left behind due to its inertia of rest. Thus the bob will have a backward swing.

(**ii**) During the steady motion of car, the pendulum bob will have regular to-and-fro swings.

(**iii**) When the car comes to a sudden stop, the pendulum bob will have a violent forward motion. It is so because the bob will have already got the forward momentum on it while the top of the pendulum comes to rest with the car.

84. (*a*) *Why is the tension in the string, when in its vertical position, greater when the simple pendulum bob is swinging than when it is at rest ?*

(*b*) *Does this difference depend on the extent of the swing ?*

Ans. (**a**) At the limits of the swing, where the bob's velocity is zero, the tension in the string will be equal to the component of the bob's weight acting in the line of the string. That is, the tension will be less than the bob's weight.

But at the centre point of the swing (*i.e.* when the string is in its vertical position), the tension in the string must not only balance the bob's weight but must also impart to it the necessary centripetal force upward. Therefore, its tension must be greater than the bob's weight.

(**b**) This difference definitely depends on the extent of the swing. At the limit of the swing, the component of the bob's weight opposing the tension in the string decreases as $\cos\theta$ decreases with increased value of θ. And at the centre point of the swing, greater and upward centripetal force will be required to raise the bob to the same height on the other end of the swing. Hence tension in the string will further increase with increased extent of the swing.

85. *Why do we lean forward while ascending a hill ?*

Ans. If we walk in a vertical position, the line of action of the weight of our body will fall outside the area occupied by our feet on the backside and so we shall fall backwards. To avoid this, we should lean or bend so much forward that the line of action of our weight passing through the C.G. of the body falls within our feet.

[**Note** : Reverse is the case when descending the hill.]

86. *Why does a rope dancer, while dancing on a rope, generally carry a bamboo (or an umbrella) in his hand ?*

Ans. If the rope-dancer is falling towards his right-hand side, he thrusts or pushes the bamboo towards his left-hand side so much that the combined C.G. of the dancer-plus-bamboo system remains vertically above the rope. Separately, the falling dancer's C.G. will lie on the right hand side of the rope, and that of the bomboo, on the left-hand side of the rope. Thus, without a bamboo, he will not be able to balance himself on the rope. Hence the reason.

[**Note** : Similarly, we can explain *why a man carrying a bucket full of water in one hand leans towards his other hand* ?]

87. *Why should a rocking toy jerk back to its initial position after getting a slap ?*

Ans. The equilibrium of a body depends on the position of its C.G. Since the whole weight of a body acts through its C.G., so it will tend to bring the body to such a position that its C.G. acquires the lowest position. The body thus attains a position of stable equilibrium and on slight displacement its C.G. will be raised.

The lower part of a rocking toy also is very heavy which keeps its C.G. quite low. On slightly tilting such a toy to one side, its C.G. is raised and hence the force of gravity acting through its C.G. brings the toy back to its original position.

[**Note** : That is why the goods are stored in the lower part of a ship. These goods serve the purpose of a *ballast*.]

88. *Why are the passengers in a boat asked to sit ?*

Ans. The passengers are asked to sit so that the C.G. of the system remains lower which keeps the boat in stable equilibrium

If the passengers stand up, the C.G. of the system will also be raised. This brings the boat in unstable equilibrium and evidently the boat would capsize* more easily.

[**Note** : For the same reason :

(*i*) the *passengers in the upper compartment of a moving double-decker bus* are not allowed to stand ;

---

*That is why most of the incidents of boat-overturning occur near the bank of a river when everybody stands up to get out of the boat first.

(*ii*) motorists are advised not to put too much heavy luggage on the roof-racks ;

(*iii*) a truck loaded with stone or iron sheets is more stable than the one loaded with hay.]

89. *Can a man, standing against a wall, so that his left shoulder and left leg are in contact with the wall, raise his right leg and in so doing not lose equilibrium ?*

Ans. *No.* A man can raise his right leg and not lose balance only in the case when the vertical line passing through his C.G. passes also through the sole of his left foot. In the position described, this cannot be so.

90. (*a*) *Why does on old man, while walking, use a stick for his support ?*

(*b*) *Why are the legs of a chair generally inclined outward ?*

(*c*) *Why does a child keep his legs as far apart as he can while learning how to walk ?*

Ans. In all these cases, the base-area of their support is increased so that the vertical line passing through C.G. continues to fall within their base even when they are slightly displaced. Thus these objects tend to acquire a state of stable equilibrium.

91. *A porter carrying luggage on his head on a level road does no work. Then why should you pay him ?*

Ans. Work is measured by the product of the force (doing work) and the distance moved *in the direction of the force.*

Her, the force is the weight of luggage acting vertically downward and in this direction the luggage is covering no distance as it remains at the same height from the ground. Therefore, no work is being done by the porter and we should not pay.

But the porter is straining his head to apply an equal and opposite reaction otherwise the luggage will fall to the ground. Moreover, with the increase of normal reaction(=wt. of porter+wt. of luggage), the porter has to work against the increased force of limiting friction between his feet and the road. Hence we have to pay him for the extra work done against friction on account of luggage on his head.

92. *A body is moving with a uniform speed along the circumference of a frictionless circular path. Is any work being done on the body ? Discuss.*

Ans. Work is measured by the product of applied force and the distance moved (by the body) *in the direction of the force.*

Here, the force acting on the body is the centripetal force directed towards the centre of the circular path. At every point this force is perpendicular to the circular path. Since the component of this force at right angles to itself and thus along the direction of motion is zero, therefore *no work* will be done on the body.

93. *An open beaker is lowered into a vessel containing water, once bottom upward, and once bottom downward, both times to the same depth. In which of the two cases will the work which must be expended on dipping the beaker into water be greater ?*

Ans. When the beaker is dipped into the water, the force which must be applied to achieve this will increase with the depth to which the beaker is dipped since the upthrust will increase. However, this force will not be the same in the two cases.

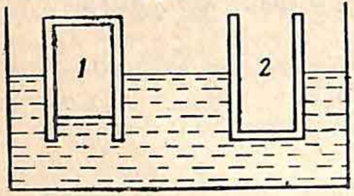


Fig. 1-36

In the first case the air inside the beaker is compressed, and the water partly enters the beaker (Fig. 1-36). Thus if the beaker be dipped to the same depth on both occasions, the volume of water displaced will be less in the first case, so the thrust will also be less than that in the second case. Therefore the force equalling this upthrust (that must be applied to dip the beaker in water) is *less in the first case*, and so is the work done by this force in immersing the beaker to the same depth.

94. *Will the work and power expended by the motor of a moving staircase (or escalator) change if a passenger standing on it as it moves upwards, himself walks up the staircase at a constant speed ?*

Ans. If a man moves up an escalator at a constant speed, the average pressure which he exerts on the staircase will remain unaltered and equal to his weight. Therefore the force with which the motor must drive the staircase will also remain the same. However, a mounting man will reach the top of the escalator sooner and therefore the distance travelled by the escalator during the period of the man's climb will be less than when the man is stationary. Hence the *work done by the motor* of the escalator in raising a moving man *will be less* than that done in raising a stationary one (the other part of the work is done by the man).

However the *power* (*i.e.* rate of doing work) which has to be exerted by the motor *remains the same* since the reduced amount of work will be done in a correspondingly reduced period of time.

[**Note** : The work done by the motor will be more if the passenger is coming down the moving escalator but the power will still remain the same.]

95. *The force-field between a pair of protons is repulsive. Does the potential energy increase or decrease as a pair of protons are brought together ?*

Ans. Since the force between the protons is repulsive, they resist being pushed together, or they fly apart, if released from rest. When accelerating apart, they are changing P.E. to K.E. There is therefore more P.E. when they are compressed and less as they go apart. The situation is analogous to that of a compressed spring.

96. *An aircraft shell has a kinetic energy and a momentum. Just then it explodes. What about the momentum and K.E. of the pieces ?*

Ans. Since no external force acts on the shell, the total momentum of the shell must remain unaltered by the explosion. Therefore, the vector sum of the momenta of all the pieces will be equal to the momentum of the shell just before it exploded.

But total K.E. of the pieces must equal the K.E. of the shell plus the work done (the chemical energy transformed into K.E. of the pieces) in the explosion. Therefore it will be greater than the initial K.E. of the shell.

97. *Is it correct to state that all our available sources of energy originally came from the sun ? Justify your answer with examples.*

Ans. The ultimate sources of supply of energy in repose are : (*a*) fuel, (*b*) food, (*c*) head of water, (*d*) tidal energy and (*e*) chemical energy. Sources of K.E. are : (*a*) air in motion and (*b*) water in motion.

Yes, it is correct to state that these are all ultimately traceable to the results of the solar days.

Wood, coal and oil were originally produced by the sun's rays, which decomposed the carbonic acid in their leaves, setting free the oxygen and leaving the carbon for use in the structure (or wood) of the plant.*

By burning a fuel (by the change of chemical energy into heat energy), water can be converted into steam which can drive an engine and thus energy is supplied.

Just like fuel, the food† is also used for producing heat and for doing work. By its gradual oxidation, it keeps up the temp. of the body and by its provision to the body of a source of energy on which the body draws for the performance of work.

Head of water derives its energy from sun's rays which at some earlier date vaporised the water on the earth's surface and this water returns to earth in the form of rains. This energy stored in the head of water can rotate dynamos to produce electricity, which in turn can do all sorts of jobs.

Tidal waves are also produced by the action of the sun and the moon upon the fluid portions of the earth which results in a very gradual slowing down of the diurnal rotation of the earth.

The air in motion rotates a wind mill. Its energy is also due to the heating effect of the sun's rays upon the earth's atmosphere. Upon being heated, the air rises and the surrounding cold air rushes in—as wind or gale—from surrounding regions.

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*The energy of sun's rays has been spent in this process—for less time in the case of wood and for many millions of years in the case of coal.

†If the food be of vegetable origin, it is derived immediately—like fuel—from the sun's energetic rays. But if the food be of animal, it has eaten the grass (sun's energy) and we have eaten its flesh.

98. *What is friction ? And what is its cause ?*

Ans. Friction is the force of resistance experienced by one body when it is made to move over the surface of another body.

Friction is due to the roughness of the surfaces in contact. The surfaces of all bodies are more or less rough and are found to be covered with minute projections. The projections on one surface appear to fit into the hollows of another, when one rests upon another. Hence to move one surface relatively to another, force must be exerted in lifting one surface sufficiently to clear the projections or in breaking some off.

[**Note** : *A sputnik is sent into orbit above the band of air.* When the booster rocket has given the sputnik the speed it needs to orbit the earth, it falls away. *There is no air to slow down the sputnik,* so it goes on travelling at the same speed round the earth without getting any extra power.]

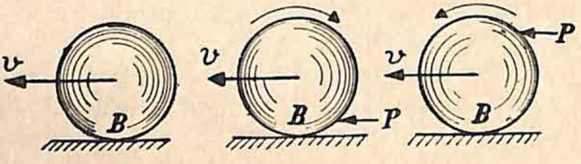
99. *A horse may be enabled to get a better grip on a slippery road by a man mounting onto its back. Why ?*

Ans. Friction can be increased by two different ways : (*i*) by roughening* the surfaces, or (*ii*) by increasing the pressure between them because the limiting friction is directly proportional to the normal reaction between the two surfaces.

Here, the normal reaction equals the sum of the weights of the horse and the man. By mounting the man onto the horse's back the normal reaction increases and hence the limiting friction between the foot and the ground correspondingly increases. This results in a better grip even on a slippery road.

100. *Why is it that when a billiards ball is struck towards the underside by the cue, it moves slowy, and when it is struck towards the upperside, it at first moves with greater speed ?*

Ans. The ball will move slowly if the force of friction is directed against the line of motion and faster if it is acting along the direction of motion. Moreover, the direction of the force of friction is opposite to the direction of the velocity with which slipping takes place at the point of contact B of the ball with the surface (Fig. 1-37-*a*).



(*a*) (*b*) (*c*)

Fig. 1-37

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*A billiard player cannot make a true shot unless there is a force of friction between the ball and the end of his cue ; so he roughens this by marking it with chalk.

If the ball be struck low with a force P towards the underside, the ball starts rotating in clockwise direction (Fig. 1-37-*b*) and the velocity at the point B determined by rotation is in forward direction and therefore slipping also occurs in forward direction. As the force of friction comes into play and acts in backward direction, the ball's motion slows down.

If the ball be struck high with the same force P (Fig. 1-37-*c*), the ball rotates in anticlockwise direction. If the ball be struck high enough, when its velocity of rotation is sufficiently great (so that the linear velocity caused by this rotation at point B is greater than the velocity v of the ball's motion in a st. line), slipping occurs in a backward direction. The force of friction comes into play, directed along the line of motion, and the ball moves faster.

101. *If a locomotive cannot move a heavy train from rest, the driver acts as follows : he puts the locomotive into reverse and then, having pushed the train back a little, switches into forward gear. Explain why this procedure allows the train to be moved forward ?*

Ans. A train usually stops in such a position that the couplings between trucks are taut. Therefore the locomotive, if it is to move the train forward, must overcome the static friction of *all the trucks* at a time. But if it pushes the train backwards, first it pushes *only the first truck* and in doing this it has to overcome the static friction of one truck. Once the truck has started moving, static friction is replaced by the sliding friction of the ball-bearings in the wheel-axles and the rolling friction of the wheels on the rails. These frictional forces are much less than that of static friction. Therefore when the locomotive pushes the first truck and the second truck backwards, it is able to overcome the second truck's static friction and so on.

After the whole train has started to move backwards and the buffers of all the trucks are compressed, the locomotive changes to forward gear. Then as it tautens the coupling of the first truck, it is overcoming at first the static friction of only the first truck, then that of only the second truck and so on, until the whole train is moving. The *compressed buffers* between the trucks also help this.

102. *What is the difference between static and kinetic (or dynamic) friction ?*

Ans. The friction between two surfaces which are stationary relative to each other is called the *static friction* while that between the same surfaces when one is moving over the other is called the *dynamic friction.*

Static friction is always greater than dynamic friction. That is why a person wishing to remain on a sloping roof or ice-slope must remain perfectly still. The instant, movement is made, friction is reduced, often with disastrous results.

103. *Why has a horse to pull a cart harder during the first few feet of its motion than later on ?*

Ans. The reason is two-fold. Firstly, the static (or starting) friction is always greater than the dynamic (or kinetic) friction. This is due to the interlocking between the projections of one surface into the hollows of the other. When the motion has started, there is no interlocking as the projections of one surface have no time to fit into the hollows of the other and therefore the grip between the two surfaces decreases.

Secondly, during the first few feet of motion, the horse has also to produce acceleration to make up speed. Once the speed becomes uniform, the force for producing acceleration disappears and then the horse has to work only against dynamic friction (which is less than the static friction).

104. *Is a large brake on a bicycle wheel more effective than a small one?*

Ans. *No.* A large brake is not more effective than a small one. Since the force of limiting friction is *independent* of the shape and *area* (or size) of the surfaces in contact so long as the normal reaction remains the same, therefore for the same applied force the brake will be equally effective whether it is large or small.

But the lever-arrangement of the brakes helps in multiplication of the pressure applied by the hand on the brakes and hence the increased normal reaction is exerted on the wheel by the brakes.

105. *Why is it particularly dangerous to drive on an icy highway?*

Ans. A force is required to produce the acceleration associated with turning, slowing, and speeding up. This force is developed between a car and the earth through the friction between tyres and road surface. The force of friction between tyres and ice is very small which makes it difficult to change appreciably either the magnitude or direction of a car's speed. Thus, on an icy road, the car will maintain its speed and direction despite brakes, throttle or steering.

[**Note** : Similarly *due to reduced friction* :

(*i*) walking on a marble floor is much more difficult than on a cemented floor ;

(*ii*) a cyclist moves faster on a marble floor than on a cemented floor ;

(*iii*) a man can move more freely on a cemented road than on loose sand.]

106. *Why can't you skate on a smooth steel plate as readily as on ice?*

Ans. The surface of a smooth steel plate has very little retarding friction on it in comparison to the smooth surface of ice, which develops little grooves under the skater's feet. The ice thus offers greater friction to the feet of the skater and makes it easier to skate on it than on the very smooth and slipping steel plate which cannot appreciably change either the magnitude or the direction of the skater's speed.

107. *Why does the pulling of a heavy box become easy when wheels are used with it?*

Ans. This is due to the fact that the sliding friction is far greater than the rolling friction. In the first case, the sliding friction comes into play when we pull the box. In the later case, it is the rolling friction that comes into play when the wheels are put under the box.

[**Note** : Frictional forces do not depend on the radius of the wheel but the work against them per revolution is proportional to the radius. Hence, less the diameter of the axle on which a wheel turns, less the losses due to friction.]

108. *How does oil reduce friction? And why is the lubrication necessary?*

Ans. When lubricated by such substances as oil or grease, the surfaces are not in actual contact but are separated by a thin layer or film of the lubricant, over which they slide. As the roughness of surfaces is smoothened, the force of friction decreases.* Evidently, the machine will give a greater output by doing work faster than otherwise.

Lubrication is essential for every machine since in its absence the machinery parts will get heated and this might injure the machine or the parts may stick together.

[**Note** : *On a muddy road*, the water provides a thin layer in-between our feet and the road. This layer serves the purpose of a lubricant and therefore the decrease in friction makes us slip on a muddy road.]

109. *"Friction† is a necessary evil". Justify this statement.*

Ans. There is no machine without friction. There is also no motion without friction. In the absence of frictional forces, it would have been impossible to walk, hold a pen, use socks, tie shoe-laces, drive a car or impossible to stop if once in motion. The brakes of a car are also friction devices.

Wicket-keepers and goalkeepers wear *rough gloves* so that the ball will not slip through their fingers. A *spin bowler* roughens the ball to help his grip. A cricket bat and bicycle handles are fitted with grips of ridged rubber or plastic.

Friction is both a help and a hindrance. It results in wear and overheating in machinery but it also makes the working of machines possible. Due to its presence, everywhere efficiency is less than 100% ; but in its absence no work can ever be accomplished.

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*The amount by which the friction is diminished depends upon the quality and nature of the lubricant.

†Earth along with its atmosphere is spinning around in a vacuum without being resisted by any friction. Hence its motion does not cease.

110. *Why is the fast bowler given a new, shiny ball ?*

Ans. There is friction between the air and the ball. A shiny ball travels faster (due to reduced friction on account of smooth surface) through the air than one that has been knocked about and had the shine removed. That is why the fast bowler is given a new, shiny ball and he polishes it on his trousers so often.

[**Note** : The surface of a boat is kept shiny by frequent painting and the barnacles are scraped off the bottom.]

111. *Why is a ladder more likely to slip when you are high up on it than when you just begin to climb ?*

Ans. When yon just begin to climb, the moment of your weight tending to rotate the ladder about its base is small and is not sufficient to cause slipping. But this moment continues to increase as you go higher and higher up on the ladder and therefore the chances of its slipping also increase.

112. *Both work and moment are computed by multiplying a force by a distance. Then why do the products represent different physical quantities ?*

Ans. In the case of work both force and distance can never be perpendicular to each other while in the case of moment they can never be paralled to each other. Thus the products of distance and force in the two cases can not have identical functions and hence the products in these two cases represent different physical quantities.

113. *What is a couple ? Can a couple be balanced by a single force ?*

Ans. A pair (*i.e.* two) of equal, unlike and parallel forces having different lines of action constitutes a *couple*. A couple has the same moment about any point in its plane and is equal to the product of either force and the arm of the couple.

A couple cannot be balanced by a single force. Although the resultant force of two equal, unlike and parallel forces constituting a couple will be zero, yet the moment of the couple about no point is zero. Hence a couple will produce rotation which cannot be stopped by the application of the third force. The effect of a couple can be neutralized only through the application of another couple possessing equal and opposite moment in the same plane or in a parallel plane.

114. *How are the three kinds of equilibrium connected with the C.G. of a body ?*

Ans. Since the whole weight of a body acts through its C.G., so it will tend to bring the body as low as possible so that its C.G. acquires the lowest position.

Evidently, in *stable* equilibrium, on slightly tilting the body, its C.G. is *raised* and hence when let free, its weight in trying to bring the C.G. down to the lowest position brings the body back to its original position.

In *unstable* equilibrium, on slightly tilting the body, its C.G. is *lowered*. Since the C.G. of a body cannot be raised without applying external force therefore when this titled body is let free, the moment of its weight tends to bring the C.G. further lower down and hence the body moves away from its original position.

In *neutral* equilibrium. the C.G. remains at the *same height* even after any amount of displacement or tilting of the body. Hence the body neither tends to come back to its original position nor topples over. Its changed position is its original position also.

[**Note** : In an ordinary **dice**, C.G. is right in the middle so that nobody knows what number will be thrown. If one side is weighted or loaded, the dice will fall with the heavy side down on the table. The crooked Shakuni of Mahabharata fame loaded his dice so that it always threw a high number and thus defeated Yadhushtra.]

115. *Why should not the Leaning Tower of Pisa fall* ?

Ans. (*i*) Vertical line through its C.G. falls within the base of the tower which indicates the stable equilibrium of the inclined tower.

(*ii*) And its foundation is sunk deep in the ground.

116. *Can you get up from the chair without moving your feet or bending forward* ?

Ans. *No.* For the man to stand up, the vertical line through his C.G. should pass through the area occupied by his feet. Therefore when we try to get up we must either bend forward to shift C.G. or shove our feet beneath the chair to place our base below C.G.

117. For *a machine, why is its* $M.A. < V.R.$?

Ans. For any machine, M.A. = Efficiency × V.R.

while, $$\text{Efficiency} = \frac{\text{output}}{\text{input}}$$

But the output (*i.e.* work done by the machine) is always less than the input (*i.e.* the work given to the machine) since a portion of the input goes waste in overcoming the frictional force or forces.

$$\therefore \quad \text{efficiency} < 1 \text{ always}; \quad \therefore \quad M.A. < V.R.$$

118. *"Whatever is gained by a machine in effort is lost in speed or distance". How can you justify this statement* ?

Ans. According to the law of conservation of energy, the energy (or work) is neither created nor destroyed. Hence the work done by a machine (known as *output*) can never exceed the work done upon it (called *input*). If we neglect friction or use a perfect machine (where friction is absent), then

$$\text{input} = \text{output}; \quad \text{or} \quad P.D. = W.d \quad \text{or} \quad \frac{W}{P} = \frac{D}{d}$$

where by applying an effort P on a machine through a distance D, the load W is raised through a distance (or height) d. Evidently

if $\quad W > P, \quad$ then $\quad d < D$

i e. whatever is gained by the machine in effort, is lost in distance (or speed since these distances are covered in the same interval of time t).

119. (*a*) *Since energy cannot be created from nothing, how is it that a man can raise a heavy weight easily if he uses a lever ?*

(**b**) *"Give me a lever of sufficient length and some place to rest it and I will move or throw away the earth". Comment on this statement of Archimedes.*

Ans. (**a**) : See answer to Q. 118 above.

Hero too, a smaller force (P) moving through a larger distance (D) does the same work as is done by a larger force (W) when being raised through a smaller distance (d) in the same time.

(**b**) : Theoretically, this statement is correct because by the principle of a lever :

$$(\text{effort}) \times (\text{effort arm}) = (\text{weight}) \times (\text{weight arm})$$

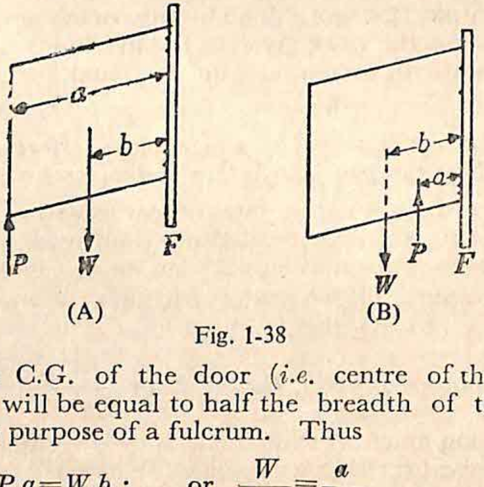
or
$$\frac{\text{wt. (of the earth) lifted}}{\text{effort applied}} = \frac{\text{effort arm}}{\text{weight arm}}$$

Hence even the earth can be moved (or thrown away) if a lever of sufficient length is available so that a longer effort arm can be used. The applied effort could be the weight of Archimedes himself.

[**Note** : But practically, this statement of Archimedes is absurd since the place for keeping the fulcrum of the lever cannot be provided. This statement simply emphasises the principle of a lever.]

120. *It is much harder to open or shut a door by applying force near the hinges than at its outer edge. Why ?*

Ans. When the applied force P **acts at its edge** (Fig. 1-38-A), then the door acts as a *lever of second type* where the effort arm (a) is equal to the breadth of the door whose weight W is acting through C.G. of the door (*i.e.* centre of the door). Thus weight arm (b) will be equal to half the breadth of the door. The hinges serve the purpose of a fulcrum. Thus



(A) (B)

Fig. 1-38

$$P.a = W.b \; : \quad \text{or} \quad \frac{W}{P} = \frac{a}{b}$$

$$\because \quad a>b, \quad \therefore \quad \frac{W}{P}>1 \quad \text{or} \quad P<W \quad ...(i)$$

Here actually $a=2b$, therefore $P=W/2$ only.

When the applied force P acts near the hinges or fulcrum F (Fig. 1-38-B), then the door acts as a *lever of third type*. Applying the principle of work,

$$P.a=W.b \quad \text{or} \quad \frac{W}{P}=\frac{a}{b}$$

$$\because \quad a<b, \quad \therefore \quad \frac{W}{P}<1 \quad \text{or} \quad P>W \quad ...(ii)$$

It is evident from the results (*i*) and (*ii*) that we have to apply a much greater force near the hinges than that at the edge of the door to open or shut it.

121. *Why do we cut a banana with our front teeth but a nut with back teeth ?*

Ans. A soft thing like banana offers less resistance (W) and hence the effort (P) to be applied to overcome this resistance will also be small. When we use front teeth, the jaw acts as a *lever of third order* (P being applied by cheek muscles while fulcrum F is near the ears) and hence M.A.<1 always. Thus $P>W$.

But a nut offers a very high resistance and hence the applied effort P to break it will be far too greater than what can be applied by the front teeth. Hence we convert the jaw into a *lever of second order* by placing the nut between F and P, and thus get M.A.>1.

122. *A man has third types of lever on his body. Is it of any advantage ?*

Ans. Since here the movement of the effort is smaller compared with that of the load, it enables us to move our hand or leg up quickly.

123. *How is any M.A. derived from the winch used for drawing water from a well ?*

Ans. Since the effort applied to the handle of the winch moves in a much larger circle than that of the drum on which the rope is wound, hence a smaller force ($=P$) acting through a larger distance does the same work as is done by a larger force ($=W$) of the weight of the water and bucket when being lifted up through a smaller distance. Thus M.A. ($=W/P$)$\gg 1$.

124. (*a*) *Is there any M.A. derived from a single fixed pulley ?*

(*b*) *If not, then why is a single fixed pulley called a machine ?*

Ans (a) There is *no* M.A. derived from a single fixed pulley because when an effort (P) applied on one end of the rope acts through a certain distance (say d), then the weight (W) hanging to the other end of the rope passing over the pulley is also raised through the same height or distance d. Hence applying the principle of work :

$$P.d=W.d\ ; \quad \text{or} \quad \text{M.A.}=\frac{W}{P}=1$$

(**b**) In reality, here M.A.<1 as there will be some friction between the rope and the pulley, and between the pulley and its axle. Yet it is called a machine. Actually any device with the help of which we *can multiply force or gain in speed* or *change the direction of the applied force* (in a more convenient direction) is known as a machine.

In the absence of the single fixed pulley, we have to apply the effort in the upward direction with the help of our arm-muscles. This would have tired us soon. But with the use of the pulley, the force is applied in the downward direction which is more convenient as it can be applied by the weight of our own body. Thus a certain muscular and physiological advantage is gained.

125. *Why is it more efficient for a labourer, to raise bricks up to a certain height by the use of a pulley than by carrying them up a ladder in a basket ?*

Ans. With the help of the rope and pulley, only the load of bricks is raised. Hence the output=input if we neglect friction. Thus

$$\text{efficiency}=\frac{\text{output}}{\text{input}}\times 100=100\%$$

But when the labourer carries the bricks up a ladder, he has to do enough additional work in raising himself also. This work goes waste. Thus

Output=work done in raising bricks only
Input=work done in raising bricks as well as himself

$\because$ Here, input$>>$output ; $\therefore$ Efficiency$<<100\%$

126. *Why is an inclined plane called a machine ?*

Ans. An inclined plane is called a machine because it helps in multiplying the force applied on it. Smaller is its angle of inclination, greater will be the multiplier obtained. With this machine, we can raise heavy weights to a certain height by applying a small force or effort.

127. *Which is more advantageous : (i) to apply force parallel to the inclined plane, or (ii) to apply force parallel to the horizontal ?*

Ans. Let l, b and h be the length, base and height respectively of an inclined plane and θ its angle of inclination.

(*i*) When the effort is applied parallel to the inclined plane, its

$$\text{M.A.}^{*}=\frac{1}{\sin\theta}=\frac{l}{h}$$

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*To increase M.A., the slope can be decreased practically by zig-zagging up the slope.

(*ii*) When the same effort is applied parallel to the horizontal to lift the same load through the same vertical height, then its

$$\text{M.A.} = \cot \theta = \frac{b}{h}$$

Since the length (l) of the plane, which is the hypotenuse of the right-angle triangle, is always greater than its base (b),

$$\therefore \qquad \frac{l}{h} > \frac{b}{h}$$

Hence it is *more advantageous to apply force parallel to the plane* than parallel to its base.

128. *What is the use of sharpening a blade or a knife ?*

Ans. The blade or knife is a kind of wedge whose

$$\text{M.A.} = \frac{W}{P} = \frac{1}{2 \sin (\theta/2)}$$

where θ is the angle of wedge. From the above relation, it is clear that M.A. increases when θ decreases and vice-versa. Since the process of sharpening results in decreasing θ, so its M.A. increases and therefore less effort is to be applied in doing any job.

129. *Which metal is better for preparing fractional weights in a weight box—aluminium or iron ?*

Ans. Aluminium is better than iron for it is a lighter metal and the fractional weights made out of it can have a size which is easy to handle. Moreover, iron gets rusted and therefore its mass will increase which is not the case with aluminium.

130. *How will you judge whether a given physical balance* is true or false ?*

Ans. Keep its pans empty and move the adjustable screws of the arms in-and-out till you find that the balance beam remains horizontal and the pointer reads zero.

Now from the weight box, take two equal weights (say 20 gm. each) and place one weight in each pan of the balance. Rotate its handle and see what the pointer reads. If the pointer still reads zero, then the balance is true, otherwise false.

131. *Can a balance be stable as well as sensitive at the same time ? And why ?*

Ans. A balance can *not* be stable as well as sensitive at the same time. The reason is that their conditions oppose one another.

A sensitive balance requires that (*i*) the length (say a) of each arm should be *maximum* which is not practicable, (*ii*) the weight (say W) of the balance should be *minimum*, and (*iii*) the distance

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*A balance has only three levelling screws because any three points can determine a plane, so the balance can be set with its beam horizontal.

(say h) of fulcrum of the beam from the C.G. of the beam of the whole balance should be *minimum.*

On the other hand, a stable balance requires that (*i*) the beam should deflect, before coming to rest, through a large angle (say θ) for no weights or for equal weights kept in the pans so that $\sin \theta$ is maximum ; this requires $\theta = 90°$ which we neither require, otherwise the beam will topple down, nor we can have as θ will be only a few degrees for no weighls or equal weights in the pans ; (*ii*) W should be *maximum*, and (*iii*) h should be *maximum.*

Thus we find the conditions (*ii*) and (*iii*) opposing one another in the two cases.

132. *Balance beam is of a broad strip and then holes are drilled in it. Why is it so ?*

Ans. For senstiveness the beam should be light. If we take a thin strip, it will not be rigid. By this arrangement of the beam, the balance will be both—sensitive as well as rigid.

133. *Why does a glass or steel ball, dropped on a stone floor, bounce higher than a stone marble ?*

Ans. Because when the glass or steel ball strikes the floor, it is slightly flattened at the point of contact, and as both these materials strongly resist this flattening, they instantly regain their former shape, with the result that they immediately spring off from the ground. The stone marble has only a feeble tendency to regain its original shape and thus does not rebound with the same force as do the steel or glass balls. This tendency to recover original shape is known as elasticity.

134. *Which is more elastic—steel or rubber ? And why ?*

Ans. Steel is more elastic than rubber.

The elasticity of length (known as Young's modulus) is defined as equal to that tensile stress which will produce unit tensile strain *i.e.* which will extend the given material to double of its original length. Therefore, if we take two wires—one of steel and other of rubber—of same length and same cross-section, then much more weight or force will be required in the case of steel than that of rubber so that the lengths of their wires become double of the original length. Since stress=force per unit area, therefore greater force will give greater tensile stress ; hence the result.

135. *Glass is harder than lead, yet a glass vase is more easily broken than a leaden one. Why is this so ?*

Ans. Hard bodies are always elastic ; elastic bodies are not necessarily hard, nor are they necessarily brittle, nor are soft bodies necessarily plastic. The glass vase breaks because it is elastic beyond the limits of its cohesion.

136. *Is there any effect of drawing, hammering or annealing on elasticity of a given specimen ? If so, what and why ?*

Ans. *Yes.* These treatments affect the elastic properties of the specimen. While drawing and hammering tend to decrease the elastic limit, annealing tends to increase it.

This is due to the fact that the elastic properties of a substance are inter-related with its fine structure. For instance, metals are aggregates of numerous fine crystals. Drawing and hammering try to set them at random inside the material, hence elastic limit is lowered, while annealing tends to put them in well-ordered directions and consequently the elastic limit is increased.

137. *Why are crane chains periodically heated* ?

Ans. Due to constant use, the crane chains get elastic fatigue and try to become brittle. The chains are periodically heated up in order that they may recover their normal strength.

[**Note** : Similarly we can explain the cause of *snapping of railway truck axles* which become more brittle as they are subjected to constant shaking and knocking.]

138. *How does the elasticity of a substance depend upon temp.* ?

Ans. The elasticity of a substance is dependent on its temp. For example, if a weight is suspended from an India-rubber cord, the cord contracts if the temp. rises and lengthens if the temp. falls. It is explained by saying that rubber contracts when heated, but the real explanation is that rubber is less extensible when hot than it is when cold.

[**Note** : Some nickel-steel alloys, *e.g.* **elinvar**, are materials whose elasticity is practically independent of temp. Elinvar = El + invar, where 'El' is the short form of 'Elasticity' and 'invar' is the short form of 'invariable'.]

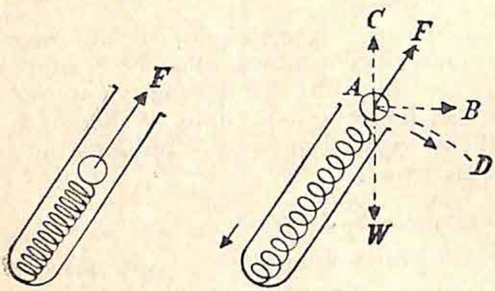
139. *Two identical springs—one of steel and the other of copper—are stretched by an identical amount. On which operation must more work be expended* ?

Ans. Young's modulus is greater for steel than for copper. Therefore, if the springs are of equal dimensions and are to be stretched by the same amount (or through the same distance), a greater force is necessary for the steel spring than for the copper one. As work done = force × distance, therefore more work is done in stretching the steel spring.

[**Note** : More work will be expended on the copper spring if both the springs are stretched with identical forces because then the copper spring will extend by a larger amount]

140. *A spring is put into a large tube and occupies the tube's full length when not subjected to outside forces. A sphere is placed on top of the spring and compresses it to approximately half its previous length. Then the tube begins to fall in an inclined position. What will happen to the sphere* ?

Ans. So long as the tube is stationary, the sphere lies in the tube and the elastic force F of the compressed spring acts on it (Fig. 1-39-*a*). But, when the tube begins to fall freely, the sphere first of all falls with less acceleration than the tube (because its weight is partly balanced by the vertical component of F) and lags behind it; the spring expands. As a result of the effect of the spring's elasticity, the sphere not only lags behind the tube in a vertical direction but also acquires velocity in a horizontal direction AB (=component of F in this direction). Therefore it will appear at the mouth of the tube with a certain horizontal velocity and will simultaneously be acted upon by the force of gravity. Hence the sphere will fall along a *parabolic* path AD onward (Fig. 1·39-*b*).



(*a*) Fig. 1-39 (*b*)

141. (*a*) *What is viscosity?* (*b*) *What is it due to?* (*c*) *How does it affect the design of ships, cars, etc.?*

Ans. (**a**) : Different fluids take different intervals of time to exhibit their fluidity, The flow of all the liquids is resisted in varying degrees and against the external force some internal force comes into play. This internal resistance offered by fluid against the external force trying to change its state is known as the force of viscosity or simply viscosity.

(**b**) : The cause of viscosity is that different layers of a fluid move with different velocities. Thus there exists a relative motion between any two layers of a fluid and it results into an internal friction produced between any two layers in contact. This internal friction hinders the flow of fluids, and is an inherent property of all fluids

(**c**) : Design of ships, cars, aeroplanes, jets, etc. depends upon viscous resistance offered by sea-water and air. To reduce this resistance, the front portion of all means of transport is kept narrow. This is known as streamlining.

142. (*a*) *What is the difference between cohesional and adhesional forces?* (*b*) *How does it help in explaining the fact that mercury does not wet glass while water does?*

Ans. (**a**) The force of attraction between the molecules of the same kind is called cohesion. It is this force which keeps the molecules of the same substance together. On the other hand, the force of attraction between molecules of different types is called adhesion. It is this force that keeps two substances together.

(b) : The force of adhesion between the molecules of glass and mercury is less than the force of cohesion between the molecules of mercury. Hence, mercury does not wet glass. On the other hand, the force of adhesion between the molecules of glass and water is more than the force ef cohesion between the molecules of water ; hence water sticks to glass or wets it.

143. *An ordinary steel needle can float on water. How and why ?*

Ans. It is due to surface tension on account of which the free surface of a liquid behaves as a stretched membrane.

Place a long and thin steel needle on a piece of blotting paper floating on water. As the paper sinks down after soaking water, the needle (covered with a very thin film of grease from our hands) continues to float on the surface of water. If the water-surface breaks, the needle will quickly sink down. This can be seen by gently pushing one end of the needle just below the surface.

144. *Why do spiders and insects move and run about freely on the surface of water without sinking, although they are heavier than water ?*

Ans. It is due to surface tension (of water) which keeps the surface of a liquid like a stretched membrane. The force of surface tenison is measured per unit length of the surface. By extending their fibres to full length, the insects bring into play enough upward force of surface tension which supports the weight of insects.

If you place an insect on the water surface after cutting its fibres, it will sink,

145. *A tiny boat which has a piece of soap or camphor attached to its stern begins to move forward when placed on the surface of water. Why ?*

Ans. The soap or camphor* dissolves in water and the surface tension of this solution is less than that of water. So water pulls the solution and along with it the boat moves forward.

After some time the whole surface of the water is contaminated and the boat ceases to move.

[**Note** : Similarly, (*i*) the oil spreads over the surface of water ;

(*ii*) Specks of soot and splinters of wood move to the side of a bowl when soap is dipped into the middle of the water ;

(*iii*) Rescues at sea are sometimes made possible by pouring oil on the water ; the reduction in the surface tension makes the large waves break up and has a local calming effect.]

146. *How do the rain-proof materials work ?*

Ans. Threads of rain-proof materials are treated with substances which have little attraction for water particles. Therefore, the theads do not become wet and the surface tension membranes on the rain-drops prevent water from running through the spaces between the threads.

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*Camphor does not dissolve equally in all directions and so it is drawn away from the side where momentarily it is dissolving most rapidly. That is why small camphor shavings dropped into pure water begin to dance about in rapid agitation.

If we touch the inside of a rain-proof tent during rain with a wet finger, we have broken the surface tension membranes of the drops and allowed them to wrap round on the inside of threads. Then water drops will start coming through the spot we have touched.

[**Note** : Similary, (*i*) the fabric of an umbrella, although porous, is impervious to rain ;

(*ii*) a drop of water remains for some time on the surface of a dry cloth before being absorbed, but a similar drop on a damp cloth is rapidly absorbed.]

147. *Can you separate water from petrol with the help of a sieve* ?

Ans. *Yes.* When the mixture is poured over a sieve with fine holes in it, the petrol will go through the holes due to its low surface tension, but the water will not as it has a high surface tension.

148. (*a*) *Why are liquid-drops spherical* ?

(*b*) *Why are bigger drops elliptical* ?

Ans. (**a**) : This is due to surface tension whose tendency is to make the surface as small as possible. For a given volume, a sphere possesses the smallest surface. Therefore, the surface tension acting equally in all directions will bring the liquid-drop to a spherical shape.

(**b**) : But as the size of the drop is increased, the increase in its weight (or volume$=\frac{4}{3}\pi r^3$) is greater than the corresponding increase in the total force of surface tension (or surface area$=4\pi r^2$). Hence a big drop assumes the shape of a flattened ellipsoid.

[**Note** : Similarly answer : How are the (spherical) lead shots manufactured ?]

149 (*a*) *A drop of oil slighty denser than water can float on water and it is then lens shaped.*

(*b*) *But a drop of the same oil formed under water has nearly spherical shape and it sinks slowly to the bottom. Explain.*

Ans. (**a**) : See answer to Q. I48 above.

(**b**) : When the oil-drop is formed under water, the force of buoyancy of water nearly balances the weight of drop which then acquires a spherical shape on account of surface tension. And because it is slightly denser than water, it then sinks slowly to the bottom.

150. *Why does water rise in a capillary tube* while mercury is depressed* ?

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*If the capillary tube is smaller than the height to which water can rise in it, the water will rise upto the top of this tube and will spread on the top assuming a convex meniscus of greater radius.

Ans. This phenomenon of capillary tube is called capillarity and is due to surface tension. A liquid rises or is depressed in the capillary tube according to whether it wets or does not wet the tube.

Water wets glass and so a film of water is formed on the inner surface of the glass capillary as the force of adhesion is greater than the force of cohesion. The water film tends to contract due to its surface tension and therefore the surface of water is drawn up along the circumference of the capillary tube [Just as a circular piece of cloth pulled upwards along its circumference will go down at its centre, so also will the water surface in this tube.]. It has thus a *concave meniscus.* The film then goes up at some other place and again due to contraction draws the water surface still higher. This goes on till the weight of the water supported is equal to the force of surface tension.

On the other hand, mercury does not wet glass. The force of cohesion between the mercury molecules is greater than the force of adhesion between the mercury and glass molecules. Hence mercury is depressed* and has a *convex meniscus.*

[The capillary rise or fall in a tube is inversely proportional to the diameter of the tube.]

[**Note** : Same reasoning applies to answer the following :

(*i*) *Why does oil rise in the wick of a lamp?*

(*ii*) *Why is a pen split at the point?*

(*iii*) *Why does a blotting*† *paper absorb ink?* (When the ink reaches the paper, capillary action causes it to soak into the holes in the surface, which is why an ink mark is so difficult to rub out. A pencil mark, on the other hand, is dry and so can easily be rubbed off the surface.)]

151. *Often, capillary attraction is a nuisance for which allowance is to be made. Cite a few examples.*

Ans. Often capillary attraction is a nuisance and we spend much time and money in preventing water from travelling along narrow 'tubes' in various materials. For example :

(*i*) Wooden doors and window-frames would swell and stick if we did not paint them with paint, creosote, etc.

(*ii*) Cloth is waterproofed in various ways to prevent it from soaking up water. A mackintosh has a thin layer of rubber ; oil skin is soaked in oil ; and a tarpaulin is cloth which has been treated with tar.

(*iii*) Cups and basins must be glazed to seal the tiny holes in pots and to prevent them from "running".

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*That is why a blotting paper does not absorb mercury.

†Drying of hands by a towel and retention of water by a sponge are further examples of capillary action.

(*iv*) Bricks too are full of holes which allow water to rise up the walls of a building from the ground. So that the building will not become damp, a layer of slate or asphalt (called *damp course*) is laid between two rows of bricks.

152. *Why is hoeing of the garden essential, particularly in dry weather ?*

Ans. It is also on account of the nuisance caused by capillary attraction. In dry weather, water rises up to the topsoil from the soil below and through the capillary tubes in soil. By *hoeing* the garden, we can break up these narrow spaces and then keep the water in the lower soil where it will benefit the roots of our plants.

153. *Why can't we make a sand pie with dry sand ?*

Ans. If we use wet sand, the surface tension of water holds the grains of sand together. The dry sand pie collapses, as soon as the bucket is removed, in the absence of any binding force.

154. *Why are the wings of an aeroplane made convex on the upper surface and concave on the lower surface ?*

Ans. According to *Bernoulli's Theorem*, for any fluid in motion, the sum total of its potential energy ($=m.g.h$), pressure energy ($=h.d.g$) and kinetic energy ($=\frac{1}{2}m.v^2$) remains constant. As these energies are mutually convertible, so a loss in one will result in gain in others. Assuming that at a given height, P.E. remains constant, then a decrease in the velocity of a fluid (so that its K.E. decreases) will bring an increase in pressure and *vice versa*.

Due to the convexity of a wing on the outer side, the boundary line of the upper surface becomes greater than that of the lower concave surface. Therefore, the relative velocity of the air above the surface of the wing becomes greater than that at its lower surface. As the K.E. of the moving air above the surface increases, the pressure above the surface becomes less than the pressure below. On account of this difference of pressures, the *lifting power* of the aeroplane increases.

155. *Why is it easier for a* $\wedge$*-shaped tin roof of a house to be blown off in a dust storm ?*

Ans. Same as for Q 154 above-

156. *Why is it dangerous to stand near a railway line when a train is passing by ?*

Ans. Same as for Q. 154 above.

The velocity of the train (increases K.E.) partially decreases the air pressure in the region between you and the train. So the outer pressure will push the viewer towards the train.

157. *How does a perfume atomiser or a spray or a flit pump work ?*

Ans. Its working is based on Bernoulli's theorem. As air is blown through a narrow tube A over the top of another tube B dipped in the liquid (Fig. 1-40), K.E. of air increases over the top of B, thereby decreasing the pressure there. Since this pressure is less than the atmospheric pressure, the liquid rises up the tube B until at the top it is blown into a fine spray by the forward-rushing air. The harder the experimenter blows, the finer are the droplets.

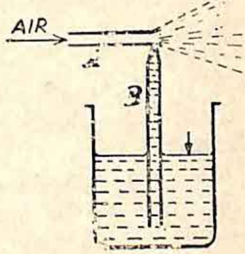

Fig. 1-40

[**Note** : *Carburettor* in a petrol engine works on this principle.]

158. *Is it possible to blow a filter paper, fitted into a funnel, out of the funnel when blowing from the narrow end ?*

Ans. It is *not possible.* The harder you blow, the more strongly is the filter paper drawn into the funnel. According to Bernoulli's theorem, the pressure in a stream of air is lowered where the stream is narrower. Therefore the pressure is lowered in the narrow gap between the filter paper and the glass funnel, and the pressure of the air from outside holds the filter paper in the funnel more tightly.

[**Note** : Similarly we can answer : *to separate thin pieces of paper from one another, it is enough to blow sideways on the edges of these pieces.*]

159. *What is the effect of spin on a tennis or cricket ball in flight ?*

Ans. The effect of spin on the ball in flight is to move it along a curve so that the ball drops faster than usual. Generally the ball is made to spin in clockwise direction. For a moment, let us imagine the ball standing still but spinning so that the relative velocity is created between the ball and the air. It produces a wind coming from the front side. At the top surface where the wind and the ball are moving in opposite directions, the air is slowed down by friction, giving rise to a high pressure (P_1) region (Fig. 1-41). On the underside, the surface moving with the wind keeps the velocity high, thus creating a low pressure (P_2) region. The resultant downward force thus causes the ball to drop faster than usual and thus deceives the player.

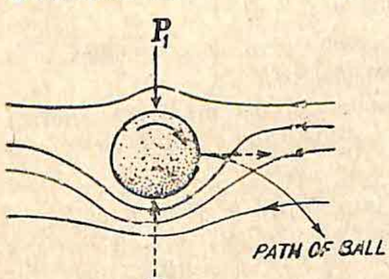

Fig. 1-41

160. *Why does a vertical stream of water or air support a ping-pong ball ?*

Ans. Here the jet of air blows past one side of the ball with a much higher velocity than the other so that the pressure in the stream of air becomes less than atmospheric pressure. The atmospheric pressure acting from the other side pushes the ball against the stream.

[**Note** : Similarly the ping-pong ball kept in an inverted funnel will not be blown off when you blow harsh through the stem of the funnel.]

161. *When you stand on loose stand, your feet sink deeply into it but if you lie down on it, your body sinks in very little. Why is this ?*

Ans. This is due to the difference in the magnitudes of pressure in the two cases. Since

$$\text{pressure} = \frac{\text{thrust or total force}}{\text{area on which thrust acts}}$$

therefore for the same thrust, pressure will be less when area is more and pressure will be more when area is less. In the given problem here, the thrust is equal to the weight of the man. When he stands on his feet, the weight of the body acts on the area covered by his feet. As this area is small, the pressure exerted on the sand becomes large and hence our feet sink deeply in it. On the other hand, when he lies down flat on the sand, the weight of the body acts on a much greater area and hence the pressure decreases. This causes the body to sink in very little.

[**Note** : Similarly answer the following questions :

(*i*) *Why is it easier to push a pin into wood than it is to push an iron rod ?*

(*ii*) *Why is a broader base used under the spiked wheels of a tank ?*

(*iii*) *Why are rails fixed over wooden sleepers ?*

(*iv*) *Why is it pleasanter to sit on a chair having a concave seat than on a flat-topped stool though both are of wood ?*

A *sofa bed* is still better since we make depressions that conform to the uneven shape of our bodies. Pressure is thus distributed evenly with a few gram/sq. cm.]

162. *If a finger is placed under a tap which is turned fully on so that only a small opening is left, the water will gush out with a greater velocity than when the tap is free to flow normally. Why does this happen ?*

Ans. The water in a water-main is under pressure (raised to several atmospheres). As the water flows along the pipe, this pressure is gradually reduced on account of viscosity until it is nearly the same as atmospheric pressure, at which it flows out of a fully open tap.

If the the tap is covered with a finger, the flow of water in the pipe ceases and so there will be no fall of pressure inside the pipe. Therefore, the water which passes through the opening still remaining will be subjected to the full pressure of several atmospheres existing in the water-main. The thin stream of water forced out by this high pressure thus acquires a much greater velocity than that of a fully open tap.

163. *Why is a dam* built broader at the bottom than at the top?*

Ans. For any fluid of density d and height h, its pressure is given by :

$$P = h.d.g$$

Since $P \propto h$, the pressure of water is very large at great depths. Therefore, the lower part of the dam should have greater thickness so that it can withstand the high pressure of the water there.

164. (*a*) *Vessels A and B of equal height contain CO_2 and H_2 gases respectively. Pressure-gauges G_1 axd G_2 register equal pressures. In which direction will gas flow if the valve K be opened (Fig. 1-42)?*

(*b*) *What will happen if the same experiment is carried out with vessels turned upside down so that the pressure-gauges are underneath?*

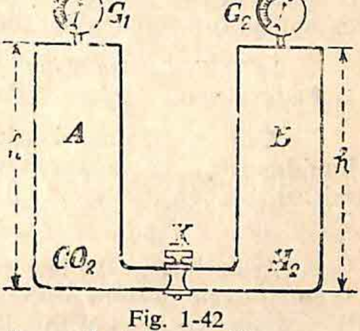

Fig. 1-42

Ans. (**a**) : The pressure on the valve K from either side will not equal the pressure registered on the gauges. we must add the pressure of a column of gas$=hdg$ where d is the density of the gas. Since the density of CO_2 is greater than that of H_2, the pressure on K from CO_2 side will be greater than that from H_2 side. Evidently, when K is opened, *a part of Co_2 will pass into the vessel B containing H_2.*

(**b**) ; In this case, the pressures at K will be $h\,d\,g$ less than those registered by the gauges If the pressure gauges read the same, then the pressure from H_2 side on K is greater thag that from CO_2 side, and when K is opened, part of H_2 will pass into A containing CO_2.

159. *Can you lift a man with the help of a few grams of water? If yes, how?*

Ans. *Yes*; a man can be lifted up with the help of a few grams of water or any other liquid. This phenomenon is known as *hydrostatic paradox* and is a direct application of Pascal's Law according to which every liquid (and gas) transmits pressure equally in all directions.

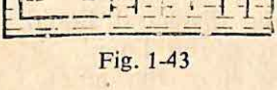

Fig. 1-43

Let us take a U tube having A and B columns of unequal cross-sections—A being quite narrow and B quite wide (Fig. 1-43). B is fitted with a water-tight piston. Fill the tube with water and let the man stand on the piston with a beaker of water in his hand. Water in A rises a bit up and then its level becomes stationary. As this man starts pouring water in A, his piston starts rising up. If at any instant, the difference of levels of water in A and B be h and d be the density of water, then the downward pressure exerted by this height of water in A is :

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*The face of the dam towards water reservior should be convex so that the dam is forced tighter together as water pushes against its face.

$$P=h.d.g$$

This pressure is equally transmitted by the water in all directions and hence it acts on the piston of B also. If the radius of this piston be r, then

upward thrust acting on the piston$=(h.d.g)\times\pi r^2$

When this upward thrust is greater than the downward-acting weight of the man, he starts rising up.

166. *Will a hydraulic press work if its cylinder be filled with a gas instead of a liquid ?*

Ans. *Yes* ; the press can work with gas also because Pascal's law is valid for gases as well as for liquids. [But its efficiency will be greatly reduced since a major part of the work done will be expended on compressing the gas.]

167. *Will the working of a hydraulic press be affected if a body is floating on the surface of the liquid in one of its columns ?*

Ans. If d be the density of the liquid and h the difference of liquid-levels in the two columns, then the pressure which is transmitted through the liquid filling the columns of the press is given by

$$P=h.d\,g$$

According to the law of floatation, the weight of a floating body is equal to the weight of the liquid displaced by its immersed part. Therefore the level of the liquid (and hence the difference of liquid levels$=h$) will not change if the floating body is replaced by the volume of the liquid displaced by the immersed part of the body. Hence the working of the press is *not affected* as the effective pressure remains constant.

168. *In order to raise the level of a liquid in a vessel by means of a pump, certain amount of work must be done. Will the amount of work required for this be altered if a body is floating on the surface of the liquid ?*

Ans. When a body is floating on the surface of a liquid, then according to A.P., its weight is equal to that of the displaced liquid. Thus, if the body be replaced by an equal weight of the liquid, the level of the liquid will not be changed. And therefore the amount of work required to raise the level of the liquid through a given height *will not change.*

169. (*a*) *A piece of ice is floating on water in a beaker. When it melts completely, will the level of water* (*i*) *go up,* (*ii*) *go down or* (*iii*) *remain the same ?*

(*b*) *What will happen if the beaker is filled with* (*i*) *a liquid heavier than water,* (*ii*) *a liquid lighter than water ?*

Ans. (a) : According to A.P., the weight of floating ice equals the weight of water displaced by its immersed part. Therefore, the volume of water which will be formed as the ice melts will be exactly equal to the volume of displaced water and the level of water in the beaker *will remain unaltered.*

(b) When the beaker contains a liquid heavier than water, as the ice melts the water so formed will have a greater volume than that of the liquid displaced by the ice. Therefore, the *level will go up.* Evidently the reverse will happen when the beaker contains a liquid lighter than water and the *level will fall.*

170. (*a*) *A piece of ice is floating in a beaker containing water and inside the ice is a piece of iron. Will the level of the water in the beaker be altered when the ice melts ?* (*b*) *What will happen if there is not iron but air bubbles inside the ice ?*

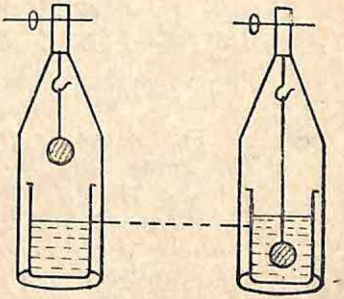
Ans. (a) : Since the piece of ice containing iron weighs more than a piece of pure ice of the same volume would do, it sinks lower in the water than piece of pure ice and displaces a greater volume of water than will be formed as the ice melts. Therefore, when the ice melts, the level of the water will *fall.*

(b) : If there are air-bubbles in the ice, the piece of ice will weigh less than a piece of solid ice of the same volume and therefore it will not sink so deep as a solid piece of ice of the same volume. However, since the weight of air bubbles can be ignored, the piece of ice displaces the same weight of water as its own weight. Hence when the ice melts, the level of the water *will not change* when the air-bubbles escape from water. (Before the air-bubbles escape from water, the level will definitely go up).

171. *A brass bob was weighed along with the beaker of water. The bob was then suspended in water from the hook of the stirrup. Will equilibrium be affected ?*

Ans. Fig. 1-44 (*a*) shows a beaker of water weighed along with a brass bob in air. When this bob is suspended in the water of the same beaker (Fig. 1-44-*b*), *beam still remains horizontal* and the equilibrium is not disturbed. It can be explained in two ways :

(1) With whatever force the bob acts on water or on the bottom of the beaker, with the same force the water reacts and pushes the bob up (Newton's third law). This force of reaction acts along the thread. Thus the apparent


(a) Fig. 1-44 (q)

loss in weight of the bob is made up fully by the force of action.

(2) Notice the level of water in the beaker. In the second case, the level of water goes up since the bob has diplaced an equal volume of water. This increased height of water increases the downward thrust of water on the beaker or the pan and fully compensates the loss of weight of the bob.

[**Note** : The pan will sink down if instead of the bob you dip your finger in the water.]

172. *If in Q. 171 above, the bob was suspended in water with the help of an outside stand, what will happen to the equilibrium of the balance beam ?*

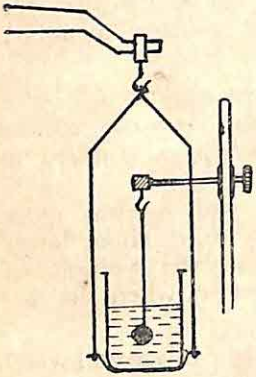


Fig. 1-45

Ans. Fig. 1-44 (*a*) shows a beaker of water weighed along with a brass bob in air. Without removing the weights from the other pan of the balance, when we suspend the bob in water with the help of an external stand (Fig. 1-45), this *pan sinks down.* The reason is that the force of buoyancy acts through the thread and becomes ineffective for this pan while the downward action of the bob or the increased thrust of water due to the increased height of water in the beaker pushes the pan downward.

[**Note** : The apparent increase in weight of the bob will be equal to the weight of an equal volume of water.]

173. *On one scale pan of a pair of scales is a beaker containing water, and on the other is a stand from the arm of which a brass bob is suspended. While the bob is not in the water, the scales are in equilibrium. Then the thread is lengthened so that the bob is entirely immersed in the water. As a result, the equilibrium is destroyed. What should be done to restore equilibrium ?*

Ans. In the beginning when equilibrium was gained with the bob outside the water, the total weights in the two pans were equal ; that is

wt. of (beaker+water) in A=wt. of (stand+bob) in B ...(*i*)

But when the bob was fully immersed in the water of the beaker (Fig. 1-46), Archimedes' principle came in the picture. An upthrust is thus exerted by the water on the bob and is equal to the weight of an equal volume of water (displaced by the bob). This force reduces the tension in

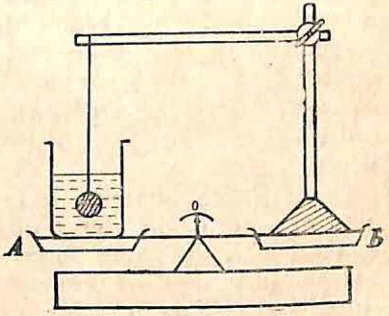


Fig. 1-46

the thread* from which the bob is suspended. Therefore.

total wt. in B=(wt. of stand)+(wt. of bob)
−(wt. of displaced water) ...(*ii*)

But, according to Newton's third law, the bob immersed in water will exert a force on the water equal to the upthrust and this is transmitted by the water in the beaker to the pan A. This additional force is apparent as the level of water in the beaker is raised by the immersion of the bob and thus the pressure on the bottom of the beaker increases. Therefore.

total wt. in A =(wt. of beaker)+(wt. of water)+
(wt. of displaced water) ...(*iii*)

From eqs. (*i*), (*ii*) and (*iii*), it is evident that the total wt. in A is greater than the total wt. in B and equilibrium can be restored *by placing in B a load equal to* **twice** *the wt. of volume of water displaced by the bob.*

174. *Why does a bucket of water appear lighter when under water than when out of it ?*

Ans. As long as the bucket full of water remains under water, it is being pushed upward by the force of buoyancy of water. This upthrust or buoyancy is equal to the wt. of the water displaced by the bucket. This not only nullifies the wt. of water filling the bucket but also decreases the wt. of the bucket also. Thus we experience a weight less than the wt. of empty bucket itself.

On the other hand, when the bucket comes out of water, we experience the wt. of not only the bucket but also that of the water filling it since the force of buoyancy of air is much less. Hence there is so much difference in the wt. of the bucket of water under these two conditions.

175. *How is it possible for a fish to move up and down in water so freely ?*

Ans. The body of a fish has several air bags. The weight of the fish acts downward while the upthrust or buoyancy (=the weight of water displaced by the body of the fish) acts upwards. When a fish wants to go to the bottom, it squeezes out air from its bags and thus decreases its volume. This reduces the force of buoyancy and the fish starts sinking down. On the other hand, when the fish wants to move towards the surface, it sucks in air dissolved in the water of lake, sea or pound, and thus increases its volume. This increases the force of buoyancy and as its downward weight remains nearly same, the fish starts coming upward.

[**Note** : *Submarine* also works like a fish but it increases or decreases its weight by drawing more water in or out of its body. By adjusting its weight equal to buoyancy, it can stay any where within water. Fish is also capable of doing so.]

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*Silk thread is preferred to cotton thread because the later sucks up ome water due to capillarity and therefore there will be a slight increase in the weight.

176. *A ship made of steel can float on water while a solid steel sphere sinks down. How does it happen?*

Ans. According to A.P., a body experiences an upward thrust when immersed in water (or any other liquid) and this force is equal to the wt. of the water displaced by the body. In the case of a solid steel sphere, the upward force of buoyancy of water is much less than its wt. acting downward. Hence the solid steel sphere sinks in water.

But in the case of ship, its body is so shaped that it displaces a larger quantity of water and therefore experiences an upthrust greater than its weight. Therefore, it floats on water such that its weight is equal* to the weight of water displaced by its immersed part. Thus the rest of the portion of the ship stays outside the water.

177. *A ship sinks into the sea. Is it possible that it may not reach the sea-bed at all?*

Ans. It is *not possible.*

A ship sinks into the sea-water because its weight is greater than the weight of water displaced by it. This resultant force (=wt. —upthrust) gives the ship a downward acceleration and therefore its downward velocity goes on increasing. When the ship sinks faster, force of friction offered by water becomes greater and so its acceleration becomes less. Ultimately, the ship attains a velocity where the force of friction becomes equal to the wt. of the ship and hence the resultant downward force becomes equal to zero. The ship then has no acceleration but sinks with a constant velocity† and reaches the sea-bed.

178. *A piece of wood released at the bottom of tank rises to its surface and floats there. But a gas-filled balloon, when released, does not ascend to the top of the atmosphere. Why should it happen?*

Ans. Since the water throughout the depth of the tank has the same density, hence when a piece of wood is fully immersed in water, it experiences a constant upthrust equal to the weight of water displaced by it. As upthrust is greater than the wt. of wooden piece, it rises till it reaches the surface. Here, to gain equilibrium, a part of it comes out of water so that its weight becomes equal to the wt. of water displaced by its immersed part.

But the density of the atmospheric air goes on decreasing as the gas-filled balloon rises higher and higher - till it reaches a height where its weight becomes just equal to the buoyancy of air (*i.e.* equal to the wt. of the air displaced by the balloon). It cannot rise further and starts moving in the direction of the wind.

179. *Why does a body weigh more in vacuum than in air?*

Ans. Archimedes' principle applies equally to both liquids and gases. Accordingly, the body experiences an *upward thurst* equal to

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*Thus the apparent wt. of a floating body is *zero.*

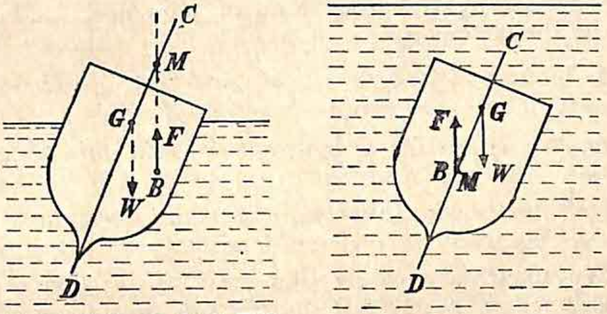
†This velocity is known as its *terminal velocity.*

the wt. of the air displaced by it. This upthrust decreases the true weight of the body when weighed in air. In vacuum, there is no upthrust as in the air. Hence a body will weigh more in vacuum than in air.

180. *Why does a sinking ship often overturn as it settles in the water* ?

Ans. The reason is that the conditions of stability for a body floating on the surface of water and for a body totally immersed in water are different.

For a stationary ship, the centre of gravity G of the ship and the centre of buoyancy B of the displaced volume of water will both lie on ship's plane of symmetry CD. In that position the weight W of the ship acting downward through G and the force F of buoyancy acting upward through B will act in the same line of action and their resultant will be zero. But when the ship slightly heels over (Fig. 1-47-*a*), for the ship to be stable it is necessary that these two forces, W and F, constituting a couple, should have a moment capable of restoring the ship to its position of equilibrium. For this purpose, the meta centre M must lie higher than the centre of gravity G of the ship.



(*a*) (*b*)

Fig. 1-47

But if the ship is entirely immersed in water (Fig. 1-47-*b*), some water gets in and $C.G.$ of the ship is raised. Here the centre of buoyancy B lies in ship's plane of symmetry CD. Since now the meta centre M lies below G, the moment of the couple (W and F) turns the ship still farther from its position of equilibrium and the ship overturns .

181. *Burning kerosene oil cannot be extinguished by pouring water on it. Why* ?

Ans. Water is heavier than kerosene oil. When we pour water over it, it sinks and therefore it cannot prevent the air (for the supply of oxygen) from coming in contact with the burning oil.

182. *When a ship passes from the fresh water of a river into the sea, does it rise higher or sink lower?*

Ans. S.G. of the salty sea-water is more than that of the fresh water. To balance the downward weight of the ship, it should displace less volume of heavier liquid and more volume of a lighter liquid. Hence the ship will *rise higher* when passing from the river into the sea.

[**Note** : For the same reason, *it is comparatively easier to swim in sea than in river.*]

183. *Why does nobody get drowned in the Dead Sea in Palestine?*

Ans. In the Dead Sea, there is a great evaporation of water due to its being below the sea-level and it is also in a hot region. Hence it has very high salt contents. Its S.G. is so high that a man does not get easily drowned in it as the upthrust will also be large.

184. *A lactometer* can be easily duped while testing the purity of milk. How?*

Ans. If we take out cream from milk, the skimmed milk becomes denser than pure milk, because cream is lighter than milk. Hence sufficient quantity of water can be mixed with skimmed milk to bring its density down to that of pure milk. This cannot be detected by the lactometer.

185. *Which hydrometer will you prefer—(a) with thin or thick stem, (b) with less or more volume? And why?*

Ans. We will prefer a hydrometer with *thin stem* and with *large volume*.

A hydrometer with thin stem will be more sensitive because by placing less weight it will sink considerably.

A hydrometer with larger volume will displace more liquid and more weight will be required to make it sink upto the mark. It will increase the accuracy of measurements.

[**Note** Hydrometer floats vertically because its C.G. and the centre of buoyancy of the displaced liquid are in the same vertical line. And its C.G. is kept below the centre of buoyancy by filling its lower cone with lead shots or mercury.]

186. *Why is mercury used in a barometer?*

Ans. (*i*) Being *opaque*, mercury is easily visible in the glass-tube.

(*ii*) It *does not wet glass* and o gives a correct low pressure reading after recording high pressure.

(*iii*) Being a very heavy liquid, it requires a *small length* of the tube. For water, the tube-length should be more than $76 \times 13{\cdot}6$ cm. $= 10{\cdot}336$ metres.

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*Lactum means milk : lactometer measures S.G. of milk.

(*iv*) It does not vaporise easily. At ordinary room-temp., its vapour pressure is negligible and hence the barometer reading is not lowered by its vapour pressure.

[**Note** : We can not use glycerine in Boyle's Law apparatus since it is hygroscopic and will absorb moisture from the atmosphere — resulting in change in its density.]

187. *Will Torricelli's experiment work if a barometer tube filled with mercury be inverted with its open end not in a trough containing mercury but in a trough containing water ?*

Ans. The Torricellian experiment *will not work* in this case. Although, in a vertical position, there will be a position of equilibrium obtaining for the two liquids, this will be unstable equilibrium, since the common C.G. of the liquids does not occupy its lowest position. Therefore the mercury will flow out of tube and the water will flow in—keeping the tube completely filled with water as the tube-length is less than 10·336 metres.

[**Note** : (*i*) The bung must be removed from a barrel in order that the contained liquid may flow out when the tap at the bottom is opened.

(*ii*) *The opening in a petrol can is not central but in one corner*, so that the air can enter. Remember that the atmospheric pressure can support a 12·8 metre high column of petrol.]

188. *Which would produce a greater inaccuracy in a barometer — the presence of a small bubble of air or of a fragment of copper of equal volume with the air ?*

Ans. *Air* will produce a greater inaccuracy.

Actually, the fragment of copper will not produce any inaccuracy. Since copper is lighter than mercury, it will float on the surface of mercury so that the downward weight of copper piece equals the upward thrust of mercury on account of immersed part of copper. Thus the piece of copper exerts no extra downward pressure and hence barometer will continue to give correct atmospheric pressure. No doubt, the volume of vacuum will decrease due to protruded part of copper, but pressure is not affected by the volume of vacuum.

But the presence of air will decrease the barometric reading since air occupies vacuum only and will exert downward pressure on the surface of mercury in the barometer.

189. *How does a barometer help us to forecast weather ?*

Ans. When the amount of water vapours or the humidity in the air increases, the density of air decreases since water vapours are lighter than air. Because pressure is proportional to density, it also decreases with increase in humidity. The gradually falling barometer therefore indicates the *approach of rain*. A sudden fall in barometer reading is a sign of *cyclone* or *dust-storm*. A rising barometer indicates the approach of *fair weather*.

190. *The atmospheric pressure is about 1·03 kg. wt. per square cm. on earth. Why do we not feel such a high pressure exerted on our body ?*

Ans. It is indeed a very high pressure exerted on us equally from all directions and which amounts to 1500 quintals of total air thrust on the body of a normal person. Still it is not felt by us because it is balanced by the outward pressure of inhaled air which reaches every part of the body after getting mixed up with the blood in the heart.

[**Note** : (*i*) People suffering from lung diseases like pneumonia feel the atmospheric pressure because their lungs do not work properly and they feel difficulty in breathing.

(*ii*) Some of the tins in which tobacco is sold have a small hole in the bottom, covered with a small rubber patch. The lid cannot be opened until the patch has been removed. It is because of vacuum in the tin so that a force of 1·03 kg. wt./cm.^{2} acts on the lid from outside.]

191. *Which is better for an aeroplane to take off into the wind or with the wind ?*

Ans. The lifting power of an aeroplane is directly proportional to the square of its relative velocity w.r.t. the surrounding air. When the plane takes off with the wind following, its relative velocity w.r.t. air equals its velocity minus wind velocity. But when the plane takes off into the wind, its relative velocity w.r.t. air equals its velocity plus wind velocity. Thus a plane taking off into the wind reaches the same air-speed at a lower ground speed than if it were to take off in a tail-wind. Hence it is *better to take off into the wind.*

192. *We are advised to empty the ink from our fountain pen before going up in an aeroplane. Why ?*

Ans. It is so because of the fact that the atmospheric pressure falls as we ascend. Since the ink partly filling our pens is held up by the pressure exerted by the atmosphere, it is likely to flow out when the aeroplane rises, because the high pressure air partly filling our pen will expand when the external atmospheric pressure decreases.

[**Note** : If a bubble of air is introduced into the bottom of a barometer, it steadily increases in size as it rises through the mercury because pressure acting on the bubble gradually decreases and by Boyle's law its volume increases.]

193. *What will happen if a hole is made in (a) gas part of the tube, (b) mercury part of the tube of a Boyle's Law Apparatus ?*

Ans. (**a**) : The gas inside will be in direct communication with air and will exert the same pressure as at the other end. The level in the two tubes, therefore, will become the same.

(**b**) : If the level of the hole is lower than that of mercury in the reservoir (or open) tube, mercury will flow out till its level on both sides is the same because the pressure inside of the hole will be greater than that outside.

If the level of the hole is higher, then air will bubble in through the hole till the level of mercury is the same on both sides since the pressure inside is less than that outside the hole.

In both the cases, the mercury will adjust its level to that of the hole in both—the tube and the reservoir.

194. *What would be the effect on the result if the enclosed air in Boyle's Law Apparatus were moist* ?

Ans. Boyle's law holds good only if the enclosed air is perfectly dry. If the air is moist, the result would be true only approximately.

195. *When a tyre is inflated, both pressure and volume are increased. Do you consider it a violation of Boyle's law* ?

Ans. *No*. We first compress (with the help of the piston in the pump) the air coming into the barrel from outside at atmospheric pressure. The compressed air then enters the tyre where it expands to fill the tube. Both the operations are in accordance with Boyle's law (except that during compression the air is slightly heated).

196. *Why do bubbles appear when a soda water bottle is opened* ?

Ans. The CO_2 is dissolved under high pressure in the soda water. But when the bottle is opened, its pressure is decreased to atmospheric pressure, and the bubbles of CO_2 appear at the opening of the bottle due to decreased solubility.

197. *Why does a vehicle lose power when it is operated at a very high altitude ? How is this difficulty overcome generally* ?

Ans. The power of a vehicle depends upon the combustion of fuel which takes place with oxygen. A vehicle loses power when it is operated at a very high altitude because of combustion difficulties resulting from inadequacy of oxygen.

This difficulty is overcome generally by mechanical devices and by addition of additives in fuel.

198. *How do jet and rocket propulsions work* ?

Ans. *Jet engine* is fed with fuel, *i.e.* petrol and air. Air sucked in at the nose of the aircraft, is compressed by a compressor and its pressure is further increased by the application of heat. When it is discharged at high velocity, a reaction is created which thrusts the plane forward. The efficiency of jet propulsion increases at the higher altitudes, in contrast to that of ordinary propeller driven air-craft in which case it tends to decrease.

Rocket propulsion is not quite the same. The rocket carries all its own explosive materials and the propulsion still takes place even if there is no air or if the air were very thin, as it is at great heights. A rocket can travel in vacuum and requires no wings but it requires only a high velocity exhaust.

199. *Why can we not produce perfect vacuum with an air-pump ?*

Ans. The degree of exhaustion produced by an air-pump after n strokes is given by the formula

$$P_n = \left(\frac{V}{V+v} \right)^n \times P$$

where P is the original pressure of air in the vessel of volume V and v is the volume of the barrel of the pump. Since $\frac{V}{V+v} < 1$, therefore $P_n = 0$ only when n = infinity, which is not possible.

Even if somehow n=infinity, even then P_n cannot be reduced to zero. The reason is that as exhaustion proceeds, a stage is reached when the pressure of the air in the vessel is too weak to open the valve at the bottom of the barrel and, therefore, further exhaustion stops.

200. *On what principle does a siphon work ? For what purpose is it used ?*

Ans. A siphon works on the principle that the atmospheric pressure can balance a liquid column of a definite height depending upon the liquid density. This height for mercury is 76 cm. at sea-level and 10·4 metres for water.

Its main purpose is to draw out a liquid continuously from a vessel at higher level into another vessel at lower level without tilting its container or without disturbing its sediment.

201. *What are the conditions of working for a siphon ?*

Ans. (*i*) It should have two arms of unequal lengths.

(*ii*) The shorter arm should be dipped in the vessel from which the liquid is to be transferred. Evidently, the lower end of the longer arm will remain below* the surface of the liquid to be transferred.

(*iii*) The vertical height of the shorter arm should not be more than that height of this liquid which can be balanced by the atmospheric pressure.

(*iv*) *It will never work in vacuum* because the atmosphere must be present to push the liquid up into the shorter arm.

202. *Why is the waste-pipe of a wash-basin connected to the vertical drainage-pipe by a siphon tube and not go straight there ?*

Ans. A certain amount of water remains inside the U-shaped part of the siphon-tube. This water works as a valve or cork, shutting the gases from the drainage-system off from the house.

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*That is why water in the bottom of a floating boat cannot be siphoned over the side.

203. *Why is oil used in a rotary oil pump ?*

Ans. The reason is twofold :

(*i*) Oil stops the leakage of outside air in the vacuum created.

(*ii*) Oil takes away the heat produced by friction between its two cylinders. In the absence of oil, these two unequal cylinders will expand unequally and so an increasing gap at the point of their contact will be created. This gap will make the pump useless.

Scientific Instrument :

1. An *altimeter* measures altitudes.
2. An *anemometer* measures wind-velocity.
3. A *barometer* measures atmospheric pressure.
4. A *barograph* records atmospheric pressure.
5. A *baroscope* shows atmospheric pressure.
6. A *chronometer* measures time.
7. A *clinometer* measures gradient or slope.
8. An *eudiometer* measures volume of gases.
9. A *fathometer* measures ocean depths.
10. A *galactometer* measures absolute purity of milk.
11. A *hydrometer* measures density of liquids.
12. A *lactometer* measures purity of milk.
13. A *rotameter* measures length of curved lines.
14. A *seismograph* records earthquakes.
15. A *seismometer* measures intensity of earthquakes.
16. A *speedometer* measures the speed (of vehicles).
17. A *spherometer* measures the curvature (of spherical surfaces).
18. A *tensimeter* measures vapour pressure.
19. A *tensiometer* measures surface tension.
20. A *viscometer* measures viscosity.

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Concise Heat

1. Heat is the agent which produces in us the sensation of warmth. It is a form of energy of the molecules in motion. Heat is not a material body (although it behaves like other physical quantities capable of measurement). It has no colour, smell, shape or detectable mass.

The effect of heat which gives us the idea of degree of hotness or coldness as compared with some standard is called **temperature.** It represents the level of heat in a body or the degree of hotness of the body. It is the temp. and not the quantity of heat, which determines the direction of flow of heat when one body is brought in contact with another body. Heat always flows from a body at higher temp. to another body at lower temp. till both attain the same temp.

2. Thermometer measures temperature. It is based on the principle that a change in temperature is accompanied by a change in one or the other physical property of a substance.

(*a*) *Liquid-in-glass thermometers* use the expansion of a liquid to indicate temp. changes.

(*b*) *Gas thermometers* use either the expansion of gases at constant pressure or the increase of pressure at constant volume.

(*c*) *Vapour pressure thermometers* are based upon the fact that the saturated vapour pressure of a liquid is a function of temp.

(*d*) *Resistance thermometers* use the change in the electrical resistance of a wire which accompanies a change in temp.

The main disadvantage of a resistance thermometer is that it cannot register rapidly varying temps. (because of the low thermal conductivity of the containing tube and of the need for balancing the metre bridge).

(*e*) *Radiation thermometers* use the change in either the quality or quantity of radiation with temp.

3. The **upper fixed point** of a mercury in-glass thermometer is the temp. of steam above water boiling at a pressure of 76 cm. of Hg. (or at sea-level).

The **lower fixed point** is the temp. of the pure melting ice.

These two fixed points have the advantage that they really are constant temps. readily reproducible anywhere in the world.

The interval between these two fixed points is termed the **fundamental interval.** It is the same for all scales and determines the size of the degree of each scale.

4. Temperature Scales : The commonest temp. scales are the Celsius (Centigrade), the Fahrenheit*, the Reaumur and the Absolute (or Kelvin's).

$$\frac{°C}{100}=\frac{°F-32}{212-32}=\frac{°\mathrm{R}}{80}$$

And $$°A=°C+273$$

5. Thermometric Substances :

(*i*) **Mercury** is used in thermometers because :

- (*a*) It does not wet or stick to the glass.
- (*b*) It quickly takes up the temperature of the surroundings *i.e.*, its sp. heat is low.
- (*c*) It has a relatively uniform expansion.
- (*d*) It is opaque and so is easily visible in glass.
- (*e*) It remains liquid over a fairly wide range of temps. Its freezing point is—39°*C* and boiling point 357°*C*.

(*ii*) **Other liquids** : Alcohol is used for low temps., freezing at —112°*C*, but it boils at 78°*C*.

Water is not used because

- (*a*) it wets the glass ;
- (*b*) it does not always expand when heated (*e.g.* from 0°*C* to 4°*C*) ;
- (*c*) its expansion is not uniform ;
- (*d*) its range is very much limited.

6. Expansion of Solids :

$$\text{Coeff. of}\left|\begin{array}{c}\text{linear}\\ \text{superficial}\\ \text{volume}\end{array}\right|\text{expansion of a solid}$$

$$=\text{fractional increase in}\left|\begin{array}{c}\text{length}\\ \text{area}\\ \text{volume}\end{array}\right|\text{per }°C\text{ rise in temp.}$$

For the purposes of calculations :

$$\text{Coeff. of linear expansion}=\frac{\text{expansion}}{\text{original length}\times\text{rise in temp.}}$$

or $$\alpha=\frac{L_t-L_0}{L_0\times t}$$

---

*What is the difference between 'one degree Fahrenheit' and 'one Fahrenheit degree' ?

Similar relations for β and γ. Thus

$$L_t = L_0\ (1+\alpha.t)\ ;\ A_t = A_0(1+\beta.t)\ ;\ V_t = V_0(1+\gamma.t)$$

7. Relations between three co-efficients of expansion :

$$\beta = 2.\alpha \quad \text{and} \quad \gamma = 3.\alpha$$

For a given solid, its α can be experimentally determined by using Pullinger's Apparatus. Then its β and γ also become known.

8. Expansion of Liquids : There are two coefficients of cubical expansion of a liquid :

(*a*) The coefficient of apparent expansion (γ_a) is the fractional increase in volume (*i.e.* the increase in unit volume) per °*C* rise in temp. when no allowance is made for the expansion of the containing vessel.

(*b*) The coefficient of absolute or real expansion (γ_r) is the fractional increase in volume per °*C* rise in temp. when allowance is made for the expansion of the vessel.

If γ_g be the coeff. of cubical expansion of the vessel, then

$$\gamma_r = \gamma_a + \gamma_g$$

Coefficient of expansion increases with rise of temp. and vice versa.

For any liquid, its γ_a can be experimentally determined with the help of a Weight Thermometer and its γ_r by using Dulong and Petit's Method.

9. Change of density with temp. : If the volume of a substance increases from V_0 to V_t when its temp. is raised from $0°C$ to $t°C$, then

$$V_t = V_0\ (1+\gamma.t)$$

If d_0 and d_t be the respective densities of the given substance of mass m at $0°C$ and $t°C$, then

$$m = d_0.V_0 = d_t.V_t\ ; \qquad \therefore \qquad \frac{d_0}{d_t} = \frac{V_t}{V_0} = 1+\gamma.t$$

10. Expansion of Water : When water is cooled, it contracts until $4°C$ is reached. On further cooling it expands until it freezes at $0°C$. At this temp., a considerable expansion occurs when water changes to ice (1 c.c. of water becoming 1·091 or almost 1·1 c.c. of ice). Water has maximum density at $4°C$.

11. Expansion of Gases :

(*a*) When a gas is heated so that the *pressure remains constant*, it expands uniformly.

All gases expand by 1/273 of their volume at $0°C$ for each °*C* rise in temp. This is **Charles's Law.**

(*b*) If a gas is heated so that its *volume* remains constant,* it is found that the pressure increases uniformly.

The pressure of all gases increases by 1/273 of their pressure at 0°*C* for each °*C* rise in temp. This is the **Law of Pressures** and is also called as the Charles's law.

(*c*) Combining Charles's Laws with Boyle's Law, we get the **General Gas Law**. If the pressure, volume and *absolute* temp. of a given mass of dry gas are respectively P, V and T, then

$$\frac{PV}{T}=\text{constant}$$

or

$$\frac{P_1.V_1}{T_1}=\frac{P_2.V_2}{T_2}=\frac{P_3.V_3}{T_3}=\ldots\ldots$$

This constant is K when we use 1 gm. of gas and R on using 1 gm. molecule of gas. Value of R is same for all gases and is about 2 calories.

12. Absolute Zero and Absolute Scale of Temp. From Charles's Law, if a gas is cooled and *remains a gas* upto—273°*C*, then its volume becomes zero (Fig. 2·1). The temp. of —273°*C* is called the **absolute zero of temp**. and is the lowest possible temp. Temps. measured from this zero are called **absolute temps**. (°*A* or °*K* from Kelvin) and can be converted to °*C* by the equation

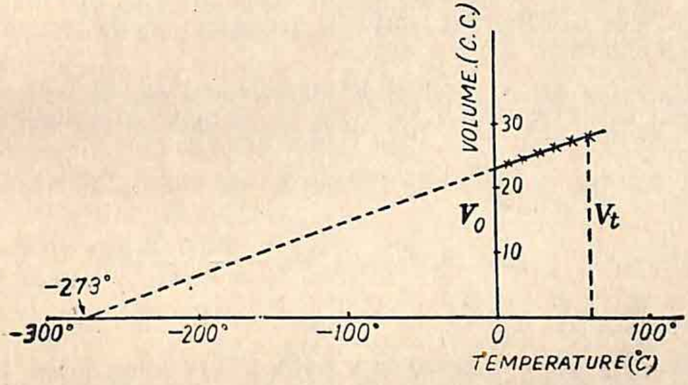

Fig. 2-1

$$°A=°C+273$$

Note : All gases not only liquefy but also solidify before 0°*A* is reached. Thus theoretically also it is not understandable how the volume of a given mass of the gas can be zero. On kinetic theory, absolute zero is that temp. at which the molecular motion will stop.

13. Units of Heat : The **calorie** is the amount of heat necessary to increase the temp. of 1 gm. of water by 1°*C* (from 14·5°*C* to 15·5°*C*).

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*In a closed oven, volume of air remains constant and hence its pressure increases. This increased pressure holds the cake or loaf in contact with the wall. The loaf will fall if the oven door is opened before the loaf is done.

The **British Thermal Unit** (B. Th. U.) is the amount of heat necessary to increase the temp. of 1 lb. of water by 1°*F*.

The **Grand Calorie** (or *Large*, Kilo or *Major Calorie*) is equal to 1000 ordinary calories.

The **therm** is the amount of heat necessary to increase the temp. of 1000 lb. of water by 100°*F* and equals 100000 B. Th. U.

The **thermie** is the quantity of heat required to raise the temp. of one tonne of water by 1°*C* and equals 3967 B. Th. U.

14. Specific Heat : (*a*) The sp. heat of a substance is the number of calories required to raise the temp. of 1 gm. of it by 1°*C*.

(*b*) The sp. heat of a substance is the **ratio** of the amount of heat needed to raise the temp. of a given mass of a substance to the amount of heat needed to raise the temp. of the same mass of water by the same number of degrees. (It is thus a pure number and has no units).

Sp. heat changes with temperature ; but this change is very small. Ordinarily it increases with increase of temp. till it becomes steady at a certain limiting temp. It decreases with decrease in temp. till at absolute zero it becomes zero.

(*c*) When a gas is heated, its pressure and volume both change. Hence a gas has two sp. heats - one at constant pressure (denoted by s_p) and the other at constant volume (denoted by s_v).

We use s_p, s_v when 1 gm. of gas is used and C_p, C_v when *1 gm. molecule* of gas is used.

$$s_p > s_v \text{ or } C_p > C_v \text{ but } \frac{s_p}{s_v} = \frac{C_p}{C_v} = \gamma$$

while $s_p - s_v = K$ and $C_p - C_v = R$

15. Quantity of heat given to a body : If the mass of a body is '*m*' gm., its sp. heat '*s*' and its temp. rises by *t*°*C*, then the quantity of heat it receives is :

$$Q = m.s.t \text{ calories}$$

This body will lose the same quantity of heat when it is cooled through the same range of temp. of *t*°*C*.

16. Law of Mixtures : In all experiments involving an exchange or transfer of heat between bodies,

Total Heat Lost = Total Heat Gained

17. Water Equivalent of a Calorimeter : It is equal to that mass (say *w* gm.) of water which takes up or gives out the same quantity of heat as is done by the calorimeter (or any other given body) when both are heated or cooled through the same range of temp. If *m* gm. be the mass of the calorimeter and *s* its sp. heat, then

$$w = m.s \text{ gm.}$$

18. Thermal Capacity of a Body : It is equal to the quanity of heat required to raise its temp. by 1°. Thus

Thermal Capacity$=m.s$ calories or B. Th. U.

It is clear that the *water equivalent of a body is numerically equal to its thermal capacity* and per unit mass of the body both of them are also numerically equal to its sp. heat.

19. Change of State : If heat is given to a solid which is a pure substance, its temp. rises to a fixed point called its **melting point**. If the supply of heat is not interrupted, the temp. remains constant at this value until all the solid has become liquid. After this the temp. rises again until the **boiling point** is reached. At the boiling point the temp. again remains constant until all the liquid has become vapour, *always provided the pressure has not been allowed to increase.*

The heat absorbed by unit mass of a substance in changing its state at its melting or boiling point is called its *latent heat.*

20. Latent* Heat : *The latent heat of fusion* is the amount of heat needed to change unit mass of a substance from solid to liquid at its melting point.

The *latent heat of vaporisation* is the amount of heat needed to change unit mass of a substance from liquid to vapour at its boiling point.

The latent heat at the critical temp. and above is zero since a gas remains gas for all pressures.

21. Melting and Boiling Points : The melting and boiling points of pure substances are constants.

Melting point is lowered by pressure increase (the phenomenon of regelation) for ice or for solids which contract on melting and by the addition of impurities (*e.g.* salt added to ice).

Boiling point is raised by impurities and by increase in external pressure, and lowered by decrease in external pressure.

22. Kinetic Theory of Matter : All matter is in a state of motion. Individual molecules are in a state of violent and irregular agitation and thus possess kinetic energy. Heating a body increases the velocity of motion of its particles and hence their kinetic energy. Thus the temp. of the body corresponds to a definite average K.E. of its molecules.

In a solid, the binding forces between molecules are sufficient to retain the solid in a definite shape. When a body is heated so that its temp. rises, the energy of agitation is increased until the binding forces become less effective and the solid loses its shape and becomes a liquid.

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* At the time of supplying latent heat, there is no rise in the temp. of the substance. When some heat given to a body causes a rise in its temp., it is called **sensible heat.**

If the temp. is further increased, individual molecules acquire sufficient energy to leave the liquid and form a vapour.

Diffusion* illustrates the validity of kinetic theory of matter. Since in gases the molecules are quite apart from one another, they are in a state of more violent and irregular agitation than in solids or liquids ; that is why the process of diffusion is more rapid in gases than in liquids.

The temp. at which all molecular motion stops and thus no K.E. is possessed by the molecules is nothing else but the zero of absolute scale of temp. $(=-273°C)$.

23. **Evaporation**	**Boiling**
1. A slow process.	A rapid process.
2. A silent process.	A noisy process.
3. It takes place at all temperatures.	It takes place at a fixed temp. (known as the boiling point of the liquid).
4. It takes place from the upper surface.	It takes place throughout the liquid.
5. It is accompanied by cooling.	During boiling, temp. remains constant.
6. Its rate increases with decrease of pressure and *vice versa*.	Boiling point is lowered with decrease of pressure and *vice versa*.

24. Factors influencing Evaporation :

(*i*) Area of the exposed or upper surface of the liquid ;
(*ii*) Dryness of the air ; (*iii*) Motion of the air ;
(*iv*) Temp. of the liquid ; (*v*) Temp. of the surroundings ;
(*vi*) Pressure acting on the surface : (*vii*) Nature of the liquid.

25. Properties of Vapours : (*i*) Liquids exposed to the atmosphere evaporate. The rate of evaporation depends upon the nature of the liquid, its temp. and the pressure.

(*ii*) Evaporation continues until as many molecules are leaving the liquid in one second as are returning to it in the same time. Here the vapour is termed as **saturated**.

(*iii*) A saturated vapour exerts pressure (called saturated V.P.) which varies with temp.

Vapour pressure above a convex surface is greater and above a concave surface is lower than above a plane surface.

(*iv*) Saturated vapours do **not** obey the gas laws, while the unsaturated vapours do.

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* Rate of diffusion of a gas is inversely proportional to the square root of its density.

(*v*) When the external pressure equals the saturated V.P. of a liquid, it boils. Hence by decreasing the pressure, the boiling point is lowered and vice versa.

26. Dalton's Laws of Partial Vapour Pressure : (1) The pressure of any saturated vapour in an enclosed space *depends upon its temp. only* and is *independent of the volume* of the enclosed space as well as of the *pressure of any other vapour or gas* already present in this enclosed space, provided that there is no chemical affinity between the two vapours.

(2) The total pressure of several vapours and gases enclosed in the same space is equal to the sum of their individual vapour pressures which the vapours and gases would have exerted when enclosed singly, provided that there is no chemical affinity between the given vapours and gases.

27. Dew Point : When a mixture of air and water vapour is cooled to such a temp. that the air becomes just saturated and the water vapour exerts its maximum pressure, this temp. at which this occurs is called the *dew point*.

Dew is not formed on cloudy and/or windy nights.

28. Relative Humidity : The relative humidity of the atmosphere is the ratio of the pressure of the water vapour in the atmosphere to the saturated vapour pressure at the same temp. It is also the ratio of the saturated vapour pressure at the dewpoint to the saturated vapour pressure at the temp. of the atmosphere.

29. Transmission of Heat : (*a*) If heat moves from one part of a body to another without any transfer of matter, it is said to be transmitted by **conduction.**

All metals are good conductors of heat, the best being copper, silver and mercury. The bad conductors of heat are air, cork, rubber, etc.

Thermal conductivity of a gas is independent of its pressure.

(*b*) If in the transfer of heat from one part of a substance to another, matter is also transferred. it is said to be transmitted by **convection.**

Convection occurs in fluids and arises because expansion occurs unevenly on heating. This causes variations in density, and the lighter part of the fluid rises. Convection is important in climatology and is put to practical use in the domestic hot-water system and the cooling of transformers.

(*c*) When heat is transferred from one place to another across empty space, it is said to be transmitted by **radiation.**

All materials radiate heat at a rate which depends upon the temp. Dull black surfaces are the best radiators (as well as the best absorbers) and polished bright surfaces are the worst radiators (as well as the worst absorbers). Evidently, a good absorber is a bad reflector and a bad absorber is a good reflector of heat.

Heat energy is lost from one body and radiant energy is emitted ; radiant energy is absorbed by another body and heat energy appears.

Light is one kind of radiant energy but not the only kind. Sources of light emit invisible radiant energy as well as the visible radiant energy we know as light. Bodies, not hot enough to give off light, still emit invisible radiant energy, *e.g.* the electric iron.

30. **Mechanical Equivalent of Heat** : Heat is a form of energy, and hence, by the law of conservation of energy, cannot be destroyed, but can be transformed into or produced from other forms of energy. The amount of mechanical work which must be done to produce unit quantity of heat is called (*Joule's*) *mechanical equivalent of heat*. It is denoted by symbol 'J'. Its value is :

$$J = 4{\cdot}2 \times 10^7 \text{ ergs or } 4{\cdot}2 \text{ joules per calorie}$$
$$= 778 \text{ ft. lb. per B. Th. U.}$$

31. **Heat Engines** :

(*a*) **Steam Engine** : It is a machine whereby steam becomes active agent. The leading types of steam engines are : (*i*) *condensing or low pressure engine* where the steam used once can be used again and again, (*ii*) *non-condensiing engine* in which the cylinder exhausts its steam into open air after using it once.

(*b*) **Petrol Engine** : In a four-stroke petrol engine, the mixture of air and petrol vapours is prepared in the carburettor and is brought to the piston chamber in the *intake stroke.* In the *compression stroke*, this mixture is compressed and the sparking plug produces a spark at its end. As the fuel catches fire, the *working stroke* starts and in the *exhaust stroke* the waste products are thrown out in the air. The cylinder is kept cooled, otherwise after sometime the fuel may catch fire in the intake stroke itself. Then the engine will stop working and requires cooling.

(*c*) **Diesel Engine** (*The Compression Ignition Engine*) : Its working is like a petrol engine except that there is no sparking plug here. Instead the air in the cylinder is compressed to over 35 kg. per square cm. pressure and its temp. comes to about 260°C. Oil injected or sprayed into the hot compressed air ignites immediately.

Steam engines are *external combustion* engines while others are *internal combustion* engines.

It is impossible for an engine, unaided by external work, to transfer heat from one body at a lower temp. to another body at a higher temp. The refrigerator is evidence of the fact that energy must be used in removing heat from a low temp. ,and discharging it at a higher temp.

Objective Type Questions

CHAPTER XV

HEAT, TEMP. AND THERMOMETRY

I. Complete the following sentences with correct word, words or phrases :

(1) Heat is a form of......

(2) Heat produced by rubbing two hands comes from......

(3) Plants grow by the heat of......

(4) Water evaporates by the heat of......

(5) Volcanoes are caused by the heat of......

(6) The ultimate source of heat on earth is......

(7) Rockets go up by the heat of......energy.

(8) Temp. is......of hotness.

(9) Our sense of touch cannot give us the correct idea of...

(10) Heat always flows from......to......

(11) The temp. of a normal person is......°*C*.

(12) Celcius scale is also known as......scale.

(13) Heat and temp. have a......relationship.

(14) Highest as well as lowest temps. can be recorded by......

(15) Lower fixed point of a Celcius thermometer is the temp. at which .....

(16) Upper fixed point of a mercury thermometer is the temp. at which......

(17) A Celcius thermometer is also known a Centigrade thermometer because .....

(18) A Fahrenheit thermometer is so-called because......

(19) Accurate thermometers have......bores and......bulbs.

(20) Interval between the two fixed points of a thermometer is termed as......interval.

II. Select the correct answers from among the brackets for completing the following statements :

(1) Energy of molecular motion appears in the form of......
[friction, temp., heat, potential energy]

(2) Thermal condition of a body is determined by its . ...
[quantity of heat, temperature]

(3) Direction of flow of heat from one body to another is determined by their...... [quantity of heat, quality of heat]

(4) Common temp. of two or more bodies brought in contact .... .obtained by adding their respective temps. [can be, cannot be]

(5) Heat is measured by a...... [thermometer, calorimeter]

(6) A hot body weighs......the cold body.
[more than, less than, as much as]

(7) Absolute zero is ..... [$0^\circ C$, $0^\circ F$, $-273^\circ C$, $373^\circ C$]

(8) Freezing point of mercury is...... [$0^\circ F$, $-130^\circ C$, $-39^\circ C$]

(9) Freezing point of alcohol is...... [$-73^\circ C$, $-39^\circ C$, $-130^\circ C$]

(10) Boiling point of mercury is...... [$212^\circ F$, $357^\circ C$, $257^\circ C$]

(11) Boiling point of alcohol is...... [$80^\circ R$, $78^\circ C$, $100^\circ C$]

(12) In Six's Maximum and Minimum Thermometer, the...... end of the index records the maximum temp. [lower, upper]

(13) In Six's Maximum and Minimum Thermometer, the...... end of the index records the minimum temp. [lower, upper]

(14) The graph between $^\circ C$ (on X-axis) and $^\circ F$ (on Y-axis) readings is......

[(*a*) a st. line passing through the origin.

(*b*) a st. line cutting an intercept on the positive side of Y-axis.

(*c*) a st. line cutting an intercept on the positive side of X-axis.]

(15) The graph between $^\circ C$ (on X-axis) and $^\circ R$ (on Y-axis) readings is...... [same alternatives *a*, *b*, *c*, as for (14) above]

(16) The graph between $^\circ R$ (on X-axis) and $^\circ F$ (on Y-axis) readings is...... [same alternatives *a*, *b*, *c*, as for (14) above]

(17) Two balls at the same temp. collide. Then......is conserved.
[temp., velocity ; kinetic energy ; momentum]

(18) In which of the following cases, the thermometer will indicate minimum temp. ?

(*a*) Blow on it. (*b*) Sit on it.

(*c*) Put it under your arm.

(*d*) Run around and get hot and then put it under your arm.

(*e*) Swing it around and around on a string.

III. Match the statements in column B with those in column A :

Column A	*Column B*
(1) Clinical Thermometer	(*a*) used for detecting heat rays.
(2) Crooke's Radiometer	(*b*) used for detecting light rays.
(3) Pyrometer	(*c*) used for measuring human temp.
(4) Differential Air-Thermoscope.	(*d*) used for showing the mechanical effect of heat.
(5) Thermo-couple	(*e*) used for measuring the expansion of bodies by heat.

CHAPTER XVI

EXPANSION OF SOLIDS, LIQUIDS AND GASES

I. Complete the following sentences by putting in suitable words or phrases :

(1) Solids, liquids and gases......when heated and......when cooled.

(2) Copper expands......than iron.

(3) Platinum expands......glass.

(4) Telegraph wires become......in winter.

(5) Iron tyres of a tonga are......than its wooden wheels.

(6) Pendulum clocks run......in summer and......in winter.

(7) Coefficient of cubical expansion is......coefficient of linear expansion.

(8) Two glass tumblers which have stuck together can be loosened by pouring......water into the inner one.

(9) Two glass tumblers which have stuck together can be loosened by immersing nearly whole of the outer one in......water.

(10) In a compensated pendulum, lengths of two metals are taken in the......ratio of their coefficients of linear expansion.

(11) A metallic thermometer is a practical application of......

(12) Different liquids have......expansions for the same rise of temp.

(13) Different gases have......expansion for the same rise of temp.

(14) A litre of petrol weighs......in summer than in winter.

(15) Mercury expands about......than glass.

(16) Water occupies minimum volume at......

(17) Coefficient of expansion of hydrogen is......

(18) In comparison to a constant volume gas thermometer, a constant pressure gas thermometer gives......accurate results.

(19) On cooling a gas at constant volume, its pressure at absolute zero is......

(20) Value of the gas constant K for hydrogen is......

(21) Value of the Universal Gas Constant R is......

(22) Volume of 1 gm. molecule of any gas at N.T.P. is......

(23) Mass of one cubic metre of air at N.T.P. is......kg.

II. Complete the following sentences by choosing the correct words from the clue given against each :

(1) The temp. of a copper disc, with a circular hole in the centre, is raised ; the diameter of the hole will......
[increase, decrease, remain unaltered]

(2) A hot glass chimney cracks when a drop of water is put on it because

(*a*) water evaporates and takes heat from that spot.

(*b*) chimney contracts at that point.

(*c*) chimney expands at that point as water changes into steam.

(3) Two evaporating dishes were heated on a sandbath. One was placed on a piece of asbestos while the other was placed on a sheet of iron. After a few minutes the......dish broke. [first, second]

(4) Two copper rods of equal lengths but unequal diameters are heated through the same range of temp. Then the increase in length will be

(*a*) more for thinner rod. (*b*) more for thicker rod.

(*c*) same for both the rods.

(5) In a compensated balanced-wheel, we use compound or bi-metallic strips. In these strips, the metal of......coefficient of linear expansion is kept on the outer side. [larger, smaller]

(6) Apparent expansion of a liquid is always......than its real expansion. [more, less]

(7) Coefficient of expansion of a liquid......with the rise of temp. [increases, decreases]

(8) During winter, water in a lake freezes first at the......
[surface, bottom]

(9) When water freezes into ice, its volume......
[decreases, increases, remains the same]

(10) Coefficient of expansion of water between 0°C and 4°C is...... [positive, negative]

(11) Ponds and lakes freeze......before they do......
[around the edges, in the middle]

(12) Aquatic animals can live in the severest winter because

(*a*) the water does not freeze at the bottom.

(*b*) the water does not freeze at the top.

(*c*) they are accustomed to live in ice.

(13) A glass globe immersed in water contains just enough air to prevent sinking. If the temp. of the water is......, the globe sinks. [raised, lowered]

(14) A football inflated in a warm room will become much...... when used outdoors on a cold day. [tighter, loose]

(15) At all temps. and at all pressures, Boyle's Law is obeyed by......gas. [a real, an ideal]

(16) A temp. of $-150^\circ C$ can be measured by the......thermometer. [mercury, alcohol, gas]

(17) A temp. of $100^\circ A$ equals......
[$100^\circ K$, $100^\circ C$, $-100^\circ C$, $-173^\circ C$]

(18) In the gas equation $P.V=R.T$, the letter V refers to the volume of......

(*a*) any amount of gas. (*b*) one litre of gas.

(*c*) one gm. of gas. (*d*) one gram-molecule of gas.

(19) A gas's behaviour is often treated as an ideal behaviour given by the equation $P.V/T=$constant. The real behaviour of the gas will be most like that of an ideal gas if......

(*a*) temp. is low.

(*b*) both temp. and pressure are low.

(*c*) both temp. and pressure are high.

(*d*) temp. is high and pressure is low.

(*e*) temp. is low and pressure is high.

(20) To make the volume of an ideal gas four times greater, we have to (while using absolute temp.)......

(*a*) double the temp. and double the pressure.

(*b*) halve the temp. and double the pressure.

(*c*) halve the pressure and double the temp.

(*d*) quarter the pressure at constant temp.

(*e*) quarter the temp. at constant pressure.

III. Some physical principles have been listed in column B. Relate them to the items given in column A below :

Column A	*Column B*
(1) Fixing of iron tyres over wooden wheels	(*a*) A bi-metallic bar becomes curved on heating
(2) Fire-alarms	(*b*) Water expands on freezing
(3) Rivetting	(*c*) Expansion of gases is very large and most uniform

(4) Thermostat	(*d*) Unequal expansions of different materials
(5) Creation of mountain-passes by nature in very cold countries	(*e*) Different metals expand unequally on heating
(6) Compensated pendulum	(*f*) Solids expand on heating and contract on cooling
(7) Compensated balance-wheel of a watch	
(8) Gas thermometer	

IV. Match the uses listed in column B with the instruments given in column A below :

Column A	*Column B*
(1) Pullinger's Apparatus	(*a*) To determine coefficient of apparent expansion of a liquid
(2) Compensated Pendulum	(*b*) To determine coefficients of expansion of a gas
(3) Weight Thermometer	(*c*) To determine coefficient of real expansion of liquids
(4) Dulong and Petit's Apparatus	(*d*) An alloy used for lead-in wires of electric bulbs
(5) Regnault's Apparatus	(*e*) To enable clocks to keep correct time in all seasons
(6) Dumet	(*f*) To determine coefficient of linear expansion

CHAPTER XVII

CALORIMETRY AND SPECIFIC HEAT

I. Complete the following sentences by putting in suitable words or phrases :

(1) Quantity of heat in a body depends upon its......

(2) Quantity of heat lost by a body depends upon its......

(3) C.G.S. units of heat are......

(4) F.P.S. units of heat are......

(5) A calorie is the quantity of heat needed to raise...... through......

(6) A therm is the quantity of heat needed to raise...... through......

(7) Sp. heat of a substance is numerically equal to the calories of heat required to raise its......through......

(8) Calorie/°*C* is the unit of......

(9) Calorie/gm./°*C* is the unit of......

(10) Sp. heat of oxygen is......than that of water.

(11) Sp. heat of hydrogen is......than that of water.

(12) Calorific value of fuels is measured with the help of......

(13) Units of heat for indicating calorific value of fuels are......

(14) For any gas, its s_v is......than its s_p.

(15) Water equivalent of any substance is......to its thermal capacity.

(16) The cooling curve obtained in Newton's Law of Cooling is called......

II. Complete the following sentences choosing the correct words from the clue given against each :

(1) 1 B.Th. U. equals......calories [352, 252, 300]

(2) Calorimeters are usually made of copper because

(*a*) it can be easily moulded.

(*b*) it is available in large quantities.

(*c*) it quickly attains the temp. of its contents.

(3) A calorimeter is kept in a wooden case surrounded by air to prevent the loss of heat by...... [conduction, convection, radiation]

(4) Calorimeters are generally polished from outside to reduce the loss of heat by...... [conduction, convection, radiation]

(5) A block of ice floating in a mass of hot water is in thermal equilibrium when

(*a*) the hot water is maintained at a constant temp.

(*b*) the ice is melting continuously.

(*c*) the system attains uniform temp. throughout.

(*d*) the temp. is uniform throughout the system and is equal to the temp. of the surroundings.

(6) Water is used in hot water bottles because its sp. heat is...... [low, high]

(7) Mercury is used in thermometers because its sp. heat is...... [low, high]

(8) Compressed air in the tube of a wheel of a cycle at normal temp. suddenly starts coming out from a puncture. The air inside

(*a*) starts becoming cooler.

(*b*) starts becoming hotter.

(*c*) remains at the same temp.

(9) Air in a metallic cylinder is suddenly compressed by a piston which is then maintained at the same position. With the passage of time, the pressure

(*a*) decreases (*b*) increases (*c*) remains the same.

(10) Sp. heat of saturated vapours is...... [positive, negative]

(11) Ordinarily, sp. heat......with increase of temp. [decreases, increases]

(12) Sp. heat of carbon or boron ..with increase of temp. [decreases, increases]

(13) According to Dulong and Petit's Law, (sp. heat)...(atomic weight) = 6·4, a constant for solids. [×, ÷]

(14) Rate of cooling for water and mercury is...under identical conditions of cooling. [same, not same]

(15) When equal volumes of water and glycerine are allowed to cool under identical conditions, their...will be equal. [rates of cooling*, rates of loss of heat]

(16) Newton's Law of Cooling is applicable when the difference of temps. between the hot body and the surroundings is... [large, small]

(17) A ball *A* has twice the diameter as another ball *B* of the same material and with same surface finish. *A* and *B* are both heated to the same temp. and allowed to cool. Then the rate of cooling of *A* is

(*a*) the same as that of *B*. (*b*) half that of *B*.

(*c*) twice that of *B*. (*d*) four times that of *B*.

(18) Cooling constant......the same constant for every liquid because it depends upon the nature *i.e.* the sp. heat of the liquid. [is, is not]

(19) There are four glass cylinders *A*, *B*, *C*, *D* of same dimensions. *A* is empty, *B* is full of water, *C* is half full of water and *D* is half full of water with food colouring. When these are placed in the sun, thermometer in the cylinder .....will go up fastest. [*A*, *B*, *C*, *D*]

(20) In Q. (19) above, thermometer in the cylinder...will record the highest temp. after, say, 3 hours. [*A*, *B*, *C*, *D*]

III. Name the scientific terms which denote the following :

(1) Mass of water which will take in or give out the same quantity of heat as is done by a body when both undergo the same change of temp.

(2) Quantity of heat required to raise the temp. of a body by 1°.

(3) Quantity of heat coming from the sun and falling perpendicularly on 1 sq. cm. area of the earth in 1 minute.

(4) Total heat gained = Total heat lost.

(5) Branch of Physics dealing with the measurement of heat.

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*Rate of cooling means fall of temp. per second while rate of loss of heat means heat lost per second.

(6) Measurement of altitude of a place with the help of boiling point of a liquid.

(7) Ratio of the rate of cooling and the mean difference of temp. of the body over the surroundings.

CHAPTER XVIII

CHANGE OF STATE

I. Name the scientific terms which denote the following :

(1) The change that takes place from the solid to the liquid state, and *vice versa.*

(2) The change that takes place from the liquid to the gaseous state, and *vice versa.*

(3) The change that takes place from the solid to the gaseous state directly and *vice versa.*

(4) The heat which does not produce a rise in temp.

(5) Amount of heat required to change a unit mass of a solid into liquid without change of temp.

(6) Quantity of heat required to change a unit mass of a liquid into gaseous state without change of temp.

(7) Melting of ice when subjected to pressure and its refreezing on removing the pressure.

(8) A mixture in which heat is lost on account of change of state of its one or more constituents.

(9) An instrument in which the mass of ice melted helps in utilising the law of mixtures.

(10) Vapours present in an enclosed space along with the liquid.

(11) Vapours whose pressure does not depend upon their volume.

(12) Vapours which do not obey Boyle's Law.

(13) A process in which a liquid changes into gaseous form from its surface silently.

(14) An instrument in which the mass of steam condensed helps in utilising the law of mixtures.

(15) The temp. where the vapour pressure of a liquid equals external pressure acting on it.

II. Complete the following sentences by putting in suitable words or phrases :

(1) Melting point of ice is...by the decrease of pressure.

(2) Melting point of iron is...by the increase of pressure.

(3) Melting point of wax is...by the increase of pressure.

(4) When iron (or ice) melts, its volume......

(5) When wax (or copper) melts, its volume......

(6) Boiling point of a liquid is...by the increase of pressure.

(7) In the dehydration of foods,...are used to hasten the drying process.

(8) Impure water boils at...temp. than pure water.

(9) The temp. of water...when sugar is dissolved in it.

(10) Cooling effect of ice is due to its...latent heat.

(11) Difference between L.H. of water and L.H. of fusion of ice is......

(12) 1 c.c. of boiling water becomes......c.c. of steam at the same temp. and pressure.

(13) On melting, 1 gm. of ice decreases in volume by...c.c.

(14) The temp. to which air must be cooled before it can be liquefied by pressure alone is called its......

III. Complete the following sentences by choosing the correct words or phrases from the clues given against each :

(1) Freezing point of sea-water is...than that of fresh water. [higher, lower]

(2) Sea-water freezes......than fresh water. [less readily, more readily]

(3) On very cold days, it is......to make snowballs. [easier, more difficult]

(4) A person skating on ice is actually skating on...... [ice, water]

(5) It is...that two bursts will occur in the same exposed water pipe during very cold weather. [unlikely, likely]

(6) Sp. heat of a substance......if the scale is °*F* or °*R* instead of °*C*. [changes, remains unaltered]

(7) Latent heat of a substance......if the scale is °*F* instead of °*C*. [increases, decreases, remains unaltered]

(8) L.H. of steam...by increase in boiling point of water. [increases, decreases]

(9) Temp. of ice-cream is......that of ice. [same as, lower than, higher than]

(10) When it is raining or snowing, the temp. of the air... [decreases, increases, remains unaltered]

(11) The air containing water vapours is......dry air at the same temp. and pressure. [as dense as, denser than, less dense than]

(12) Unsaturated vapours obey Boyle's Law... [approximately, fully, not at all]

(13) Unsaturated vapours obey Charles's Law... [approximately, fully, not at all]

(14) A vigorously boiling liquid has a......temp. than the same liquid boiling slowly. [higher, lower, same]

(15) Solids dissolved in liquids...the boiling point. [raise, lower]

(16) Once the water in a pan has begun to boil, the food being cooked in the pan...more quickly when the heat is increased. [cooks, does not cook]

(17) Evaporation occurs...rapidly in a vacuum than in air. [more, less]

(18) Vapour pressure of a salt solution is......than that of pure water. [lower, higher]

(19) The boiling point of a liquid is affected by...

(*a*) external pressure ; (*b*) external vapour pressure ;

(*c*) addition of soluble solid ;

(*d*) addition of non-soluble solid.

(20) A beaker of water is placed on a table. It can be made to boil by passing steam through it at a pressure...the atmospheric pressure. [equal to, lower than, higher than]

IV. State the physical principles involved in the case of the following :

(1) Formation of snowballs. (2) Motion of glaciers.

(3) Bunsen's ice-calorimeter. (4) Refrigerator.

(5) Ice-cream machine. (6) Ammonia ice-plant.

(7) Pressure cooker.

CHAPTER XIX

HYGROMETRY

I. Complete the following sentences with correct words or phrases :

(1) Absolute humidity is the mass of water vapour actually present in...

(2) Relative humidity is the ratio of the actual vapour pressure at room temp. to...

(3) Dryness or wetness of air is determined by......and not by ......

(4) Relative humidity is the ratio of saturated vapour pressure at dew point to...

(5) Dew point is the temp. at which the actual water vapour present in air is...

(6) When it is raining, the dew point is...

(7) When it is raining, the relative humidity is...

(8) When it is raining, the difference between the readings of the wet bulb and dry bulb of the hygrometer is

(9) Mist is formed due to the condensation of water vapours on...

(10) When mist becomes thick, it is called...

(11) Hoar-frost is nothing but...

(12) Maximum vapour pressure at the dew point...

(13) Maximum vapour pressure of water at 100°*C* *i.e.* at its boiling point is...

II. Select the correct answers from among the brackets for completing the following statements :

(1) ...is an instrument used for measuring humidity of air. [Hydrometer, Hygrometer, Barometer]

(2) The air containing water vapours is...the dry air at the same temp. and pressure. [as dense as, denser than, less dense than]

(3) If the difference between the readings of the dry bulb and wet bulb be large, it shows greater degree of...of the air. [wetness, dryness]

( ) Human breathing...the dryness of air at that place. [increases, decreases]

(5) Heating the air in a room causes the relative humidity to be... [increased, decreased]

(6) Presence of a person...the formation of dew. [accelerates, retards]

(7) No dew is formed when the sky is... [clear, cloudy]

(8) No dew is formed when the night is... [calm, windy]

(9) Rate of dew-formation increases when the relative humidity is... [high, low]

(10) More dew is formed on...of heat. [conductors, bad conductors]

(11) Maximum dew is formed... [near the ground, on the top of the building, higher up in the sky]

(12) Dew point is...when water is sprayed into a room. [raised, lowered]

(13) Mist is...in a dust-free vacuum. [formed, not formed]

(14) When the rate of evaporation of water is more under identical conditions, the relative humidity of air is... [high, low]

(15) When the atmospheric pressure decreases, the rate of evaporation of water... [increases, decreases]

(16) ...air is necessary for spinning and weaving cotton.
[Dry, Wet]

(17) When the relative humidity is very high, we feel...
[oppressed, pleasant]

(18) When a khus-khus tatti is used to cool a room in summer, the air temp. in the room drops to its
[wet-bulb thermometer reading, dry bulb thermometer reading, dew point, minimum temp.]

(19) Out of the following sets of temps. of dry and wet bulb thermometers, the one which will indicate a rainy day is...
[(37°, 15°C), (35°, 33°C), (30°, 20°C), (25°, 10°C)]

III. Which of the following statements are wrong? Also correct the wrong statements :

(1) Frost is formed by the freezing of air.

(2) Hail-stones are formed when the cloud freezes.

(3) Dew is readily formed when the absolute humidity of air is high.

(4) Dew forms more often in hollows among high ground than on the high ground.

(5) Saturated vapour pressure of any liquid is independent of the volume of the enclosed space.

(6) When the temp. of saturated water vapours is raised at constant volume, its pressure increases.

(7) When the volume of saturated water vapours is decreased at constant temp., its pressure increases.

(8) A person in an air-conditioned room at 90°F feels much cooler than in an ordinary room at about the same temp.

IV. Match the statements in column B with those in column A :

Column A	*Column B*
(1) Chemical Hygrometer	(*a*) studies effect of temp. on the vapour pressure.
(2) Daniell's Hygrometer	(*b*) measures relative humidity.
(3) Regnault's Hygrometer	(*c*) measures absolute humidity.
(4) Wet and Dry Bulb Hygrometer	(*d*) measures dew point directly.
(5) Regnault's Apparatus	(*e*) controls the condition of incoming air.

CHAPTER XX

MODES OF HEAT TRANSMISSION

I. Complete the following sentences with correct words or phrases :

(1) In conduction, heat travels..... the movement of the particles.

(2) In convection, heat travels..... the movement of the particles.

(3) In conduction and convection, medium is...

(4) In radiation, heat travels...heating the medium.

(5) In radiation, medium is...

(6) Conduction and convection are.. processes while radiation is a...process.

(7) Velocity of thermal radiations equals...

(8) In conduction and convection, heat travels along......path while radiant heat travels along...path.

(9) Heat of the sun reaches earth by...

(10) A hand held over a fire receives heat by...

(11) A hand held in front of a fire gets heat by...

(12) A room heated by hot water pipes running along the floor receives heat by...

(13) Radiant heat is non-luminous...

(14) Water is a...conductor of heat.

(15) A good absorber is a...reflector of heat.

(16) A good reflector is a...absorber of heat.

(17) A good radiator is a . absorber of heat.

(18) A poor radiator is a...absorber of heat.

(19) For all surfaces, the ratio of radiating power and absorbing power is...

(20) Rough and dull-coloured clothes are...of heat.

(21) Polished and bright surfaces are...of heat.

(22) Radiant heat obeys the laws of...

(23) A body, which absorbs 100% of all radiations falling upon it, is called a...

II. Complete the following sentences choosing the correct words from the clue given against each :

(1) When we sit before an electric heater, the heat reaches us by... [conduction, convection, radiation]

(2) A cold body...heat. [also radiates, does not radiate]

(3) When a burning coal is placed on a piece of fine muslin cloth stretched over a copper vessel, it... [will burn, will not burn]

(4) Land warms up or cools off more...than water. [slowly, quickly]

(5) The ocean gets heated more slowly than the land because the sun's rays penetrate water to a...depth. [less, greater]

(6) In windy weather, fur-lined gloves are...than fur-covered gloves. [warmer, colder]

(7) Radiant heat...polarised. [can be, cannot be]

(8) Two thin blankets are...a single one of the same thickness. [as warm as, warmer than]

(9) In the steady state of a heated rod, its sp. heat plays... [an important part, no part]

(10) Despretz's method is used for comparing thermal conductivities of two... [solids, liquids, gases]

(11) Ingen-Hausz's apparatus is used for comparing thermal conductivities of two... [solids, liquids, gases]

(12) In determining the thermal conductivity of a solid by Searle's apparatus, the body is used in its...state. [variable, steady]

(13) Substances through which radiant heat can pass are called ... [diathermanous, athermanous]

(14) Substances which absorb radiant heat are called... [diathermanous, athermanous]

(15) A black spot on a platinum foil appears...than the platinum itself at low temperature. [darker, brighter]

(16) A black spot on a platinum foil appears......than the platinum itself at high temp. [darker, brighter]

(17) If a piece of black cloth and a piece of white cloth are laid on the snow, it is observed that the......cloth remains on the surface whereas the......cloth sinks into the snow and makes a depression. [white, black]

(18) A hollow wall packed with sawdust is......effective in preventing heat from entering or leaving a room than a hollow wall which contains only air. [less, more]

(19) Thermal conductivity usually......with increasing temp. [decreases, increases]

(20) A layer of snow will......crops at the time of severe frost. [protect, damage]

(21) Trodden snow on the footpath melts......than the untrodden snow beside it. [slower, faster]

(22) In sunlight, dirty snow melts......than the clean snow. [slower, faster]

(23) To insulate a cold-storage cupboard, the ice should be placed at the......of the cupboard. [top, bottom]

(24) Which of the following cylindrical rods will conduct most heat when their ends are maintained at the same steady temps. ?

(*a*) Length 50 cm ; radius 1 cm.
(*b*) Length 100 cm ; radius 1 cm.
(*c*) Length 100 cm ; radius 2 cm.
(*d*) Length 50 cm : radius 2 cm.

(25) The conductivity of a super-conducting material is

(*a*) zero (*b*) small (*c*) large (*d*) infinite

(26) It is hotter the same distance over the top of a fire than it is in the side of it mainly because......

(*a*) air conducts more heat.
(*b*) heat is radiated upwards.
(*c*) convection takes more heat upwards.
(*d*) convection, conduction and radiation all contribute significantly in transferring heat upwards.

(27) Pressure of sunlight is responsible for the motion of a comet seen travelling with its tail always......the sun.

[towards, away from]

III. Name the scientists with whom you would associate the following :

(1) Safety lamp for miners.

(2) Accurate method of determining thermal conductivity of a solid.

(3) Theory of thermal exchanges.

(4) A simple apparatus to study the steady state of a heated rod.

(5) An apparatus using $K_1 : K_2 = l_1^2 : l_2^2$ for comparing thermal conductivities of two solids under steady state.

(6) The temp. at which a body becomes red-hot and becomes visible in a dark room.

(7) An apparatus used for comparing the radiating powers of various surfaces.

(8) The law that "the rate of emission of radiant heat from any surface is directly proportional to the fourth power of the absolute temp. of the surface—provided that the given surface is at a temp. much higher than that of the surroundings".

(9) The law that "the rate of emission of radiant heat from any surface is directly proportional to the difference of temps. of the surface and the surroundings—provided that this difference is small".

IV. Name the physical principles involved in the case of the following :

(1) Davy's safety lamp.
(2) Ocean currents.
(3) Land and sea breezes.
(4) Double-fly tents.
(5) Hot-water system in big buildings.
(6) Trade winds.
(7) Ventilation, lantern, Factory chimneys.
(8) Wrapping of ice in gunny bags or blankets.
(9) Greater warmth of woollen clothes than cotton ones.

CHAPTER XXI

MECHANICAL EQUIVALENT OF HEAT AND HEAT ENGINES

I. Complete the following sentences with correct words or phrases :

(1) $J=$......joules/calorie.

(2) $J=$......ft. lb./B. Th.U.

(3) 1 calorie=......ergs of work.

(4) 1 gm. of water, when heated from $0^{\circ}C$ to $100^{\circ}C$, acquires ......additional mechanical energy.

(5) 1 gm. of water at $0^{\circ}C$ is converted into steam at $100^{\circ}C$. It has acquired......additional mechanical energy.

(6) Any energy transformer is called......

(7) A machine which is utililized for converting heat energy into mechanical energy is called......

(8) The efficiency of a boiler is......by the layer of gas which forms on the outer surface of the boiler.

(9) The efficiency of a boiler is......by the layer of scale which is deposited on the inner surface of the boiler.

(10) When 0·93 watt hour of energy is supplied to a block of ice weighing 10 gm, it is found that......melts.

II. Complete the following sentences choosing the correct words from the clues given against each :

(1) Heat is...... [a degree of hotness, a form of energy, an invisible fluid called caloric]

(2) Steam engine is an......combustion engine. [internal, external]

(3) Petrol or Diesel engine is an......combustion engine. [internal, external]

(4) The efficiency of a petrol engine is......that of the steam engine. [less than, greater than]

(5) In a steam engine there is/are......dead centre/centres in each cycle of the piston. [one, two or more]

(6) In a steam engine, a dead centre is overcome by the use of..... [high pressure steam, flywheel]

(7) In the case of a four-stroke petrol engine, the real useful work is done in its......stroke. [suction, compression, explosion, exhaust]

(8) In the case of a four-stroke petrol engine, the sparking plug ignites the fuel at the end of......stroke. [suction, compression, explosion]

(9) At Bhakra Dam, the temp. of the falling water at the base of the dam is......that at the top. [more than, less than, as much as]

(10) The temp. of the fountain water is......that of the tap water. [more than, less than, as much as]

(11) Efficiency of a......steam engine is greater than that of a......steam engine. [condensing type, non-condensing type]

(12) If the steam goes directly into the air, the engine is a..... pressure engine. [high, low]

(13) When a condenser is used, we have a.... pressure engine. [high, low]

(14) At high speeds, the turbine is..... efficient than the reciprocating engine. [less, more]

(15) The Diesel engine uses a .....fuel than the gasoline engine. [costlier, cheaper]

(16) Kinetic Theory of Gases is based upon

(*a*) experimental observations of molecules.
(*b*) assumptions that are considered vague and doubtful.
(*c*) assumptions that are considered valid because the results of the theory agree with the experimental data.

(17) When temp. of a gas is kept constant and the volume is reduced, the pressure that the gas exerts on the walls of the container increases because

(*a*) each molecule hits the walls with greater speed.
(*b*) each molecule loses more energy when it strikes the wall.
(*c*) each molecule loses more momentum when it strikes the wall.
(*d*) the number of molecules striking the wall per unit time has increased.

(18) A vessel contains equal numbers of hydrogen and oxygen molecules and the total pressure is 760 mm. of mercury. If all the oxygen molecules are removed from the vessel,

(*a*) pressure inside the vessel will fall to half the value.

(*b*) pressure inside the vessel will remain unchanged.

(*c*) pressure inside the vessel will be 1/8th of the original pressure.

(19) According to the Kinetic Theory of Gases, the molecules of two gases at the same temp. and pressure have the same average K.E. Then the average velocity of hydrogen molecules will be...... that of oxygen molecules.

(*a*) equal to, (*b*) greater than, (*c*) less than.

(20) If hydrogen and oxygen gases exert the same pressure at the same temp., then on the average the hydrogen molecules will strike the walls of the container per second......the number of oxygen molecules striking the walls per second.

(*a*) 4 times, (*b*) 16 times, (*c*) 1/4th.

(21) An inventor claims to have made an engine which consumes 1 gm. of fuel per second (of calorific value=2 kilocalories per gm.) and delivers 10 kilowatt of power.

(*a*) This is possible. (*b*) This is impossible.

(*c*) The possibility of the invention is determined by the design of the engine.

(*d*) The possibility of the invention is determined by the nature of the fuel used.

III. Name the scientists with whom you would associate the following :

(1) Heat is a form of energy.

(2) The first person who determined experimentally the value of conversion factor for work done and heat produced by it.

(3) Frictional-cone method for experimental determination of *J*.

(4) Experimental determination of *J* with the help of two sp heats of a gas (at constant pressure and at constant volume).

(5) Steam engine.

(6) Four-stroke petrol engine.

Short-Answer Questions

1. *Why is pure ice used for marking the lower fixed point and the steam for marking the upper fixed point of a thermometer ?*

Ans. A constant temp. bath is provided by the pure melting ice at $0°C$ or $32°F$ and by boiling water at $100°C$ or $212°F$. The temp. of the boiling water does not represent the true boiling point due to the impurities in water. The *b.p.* of pure water at the atmospheric pressure is exactly the temp. of the steam at that pressure. Hence their use.

2. *What do you mean by room temp. ?*

Ans. It is the temp. of air inside a room. It is noted by suspending a thermometer in a beaker containing fresh tap water. Greater constancy of temp. is ensured by the water placed in the room than by the air.

3. *What can be the range of a mercury thermometer ?*

Ans. The highest temp. which can be recorded by it is $357°C$ and the lowest is—$39°C$.

If the space above mercury is filled with nitrogen gas under pressure, the highest temp. can be measured upto $500°C$ (because increase of pressure raises the boiling point of a liquid). This limit is due to melting point of glass. Using nitrogen and replacing glass by silica, mercury can be used to measure temps. upto $750°C$.

4. *Why do haystacks catch fire without any apparent cause ?*

Ans. Because the hay has been stacked damp or the rain has made it so. The wet hay decays and undergoes a state of fermentation, during which process great heat is produced. As this heat can not escape, so it sets the stack on fire.

5. *Does heat always produce light ?*

Ans *No* Many metals and substances can be heated without producing light. An oxy-hydrogen blow lamp, though giving a heat of over 800°C, gives a flame which is scarcely visible in the daylight.

6. *Why is a hot thing cooled while a cold thing warmed by blowing our breath on it ?*

Ans. Temp. of our breath is $36{\cdot}9°C$ (or $98{\cdot}4°F$) *i.e.* the temp. of our body. We know that heat flows from a body at higher temp. to another at lower temp. till there is an equalization of temps. Thus a hot thing will lose heat to our breath while a cold thing will gain heat from our breath blown on it to equalize their temp. Hence the required effect.

7. *A patient washes a clinical thermometer in boiling water. When the doctor uses it, he finds it useless. Why ?*

Ans. A clinical thermometer is usually graduated from 35°C to 45°C because a person will die at 35°C due to weakness and at 45°C due to overheating when the tissues are burnt out. Since the boiling point of water is 100°C, therefore when the clinical thermometer is washed in boiling water, mercury will expand and finding no room for expansion will break the thermometer bulb (which is usually very thin and is thus its weakest point). As mercury has run out of the thermometer, it has become useless.

8. *A clinical* thermometer is kept in a patient's mouth for 2 or 3 minutes. But after taking it out, mercury can be jerked down after a lapse of just a few seconds. Why is it so ?*

Ans. At first the difference in the temps. of patient (or any person) and thermometer is large and therefore mercury expands rapidly. But as this difference becomes quite small, the heating of the thermometer takes place slowly and hence the mercury also expands quite slowly. Evidently, we should keep the thermometer bulb in the patient's mouth for a considerable time.

On the other hand, when the thermometer is taken out, there is a great difference in the temps. of mercury and the surrounding air. As mercury will contract rapidly in the bulb there will be enough space, even after a few seconds, in the bulb for the mercury in the stem to be jerked down.

9. *How can you measure the temp. of stars ?*

Ans. It is generally done by studying the distribution of energy in the spectrum of stars. The wavelength (λ_{max}) corresponding to the maximum energy is taken in account in the formula

$$T.\lambda_{max}=b \text{ (a constant)}$$

where $b=0{\cdot}2884$ cm. × °A and T is the required temp. in degrees absolute.

10. *What is the lowest possible temp. ?*

Ans. The molecules in any state of matter move slowly and contract on cooling. It has been proved that at 273° below zero degree Celsius, all the molecular motion ceases, its volume becomes zero and at this point there is "no temp." It is called absolute zero ($=-273°C$). Nobody has succeeded in producing this temp. so far.

11. *Why does a solid expand on heating ?*

Ans. All substances are made up of molecules having kinetic energy. On heating, they get an extra K.E. which increases the extent of their vibrations. This results in expansion.

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*The glass of the stem of a clinical thermometer is designed to act as a lens so that the mercury thread is magnified and thus more easily read.

12. *Do all the substances expand by heat ?*

Ans. *Yes, mostly it is so.* But there are several exceptions. For example :

(*i*) The volume of water decreases when it is heated from 0°*C* to 4°*C*. [Water has minimum volume and so maximum density at 4°*C*. At this temp. it enables animals to live under water even in severe winter.]

(*ii*) Below – 80°*C*, silica contracts on heating.

(*iii*) Below 142°*C*, silver iodide also contracts on heating.

(*iv*) Stretched rubber, stretched leather, etc. also contract on heating.

[**Note** : Such substances, which contract on heating, have *negative coefficient of linear expansion.*]

13. *Why do water pipes sometimes burst in winter ?*

Ans. Due to the outside cold, water in the pipe freezes into solid ice, *i.e.* water expands. This force of expansion is sometimes so great on the sides of the pipe that it causes it to burst, and thus makes room for its increased volume.

14. *Why are iron wheel-tyres made red hot before being placed over the wooden wheels ?*

Ans The iron-wheel (rim) is made a bit smaller than the wooden wheel. On heating, the iron-wheel expands and so it can be put over the wooden wheel. Then cold water is poured on it and the rim contracts on cooling and grips tightly on the wheel, holding firmly together the whole assembly.

15. *When you rub your hands together vigorously, they warm up but finally reach a maximum temp., no matter how long you rub. How can you account for this ?*

Ans. Temp. of your hands will continue to rise as long as the mechanical energy of rubbing or friction transferred onto them per unit time is greater than the heat energy flowing out of them per unit time. With the rise of temp. of your hands, the rate of heat-flow rises because it is proportional to the difference in temps. of your hands and the surrounding air. When you reach a point at which heat flows out as fast as mechanical energy is put into your hands, their temp. will rise no further.

16. (*a*) *A piece of metal and a piece of wood are at the same temp. Why does the metal feel colder to the touch than the wood, when cold, and hotter than wood when hot ?*

(*b*) *At what temp. will the metal and the wood both feel as though they are at the same temp. ?*

Ans. (**a**) : Thermal conductivity of metals is greater than that of wood. When they are hot, *i.e.* at a temp. higher than that of our body, the metal will transmit to our body, on contact, more heat in unit time than will the wood. And if the metal is colder than our body, it will take from our body in unit time more heat than wood at the same temp. will. Therefore, in the first case metal will seem hotter than wood, and in the second case it will seem colder.

(**b**) : Evidently, when the metal and the wood are both at the same temp. as our body, they will seem equally hot when touched since there is no transference of heat.

[**Note** : For the same reason, *a carpet feels warmer to the feet than does a stone floor in winter.*]

17. *Why are telegraph wires often given a sag ?*

Ans. It is done to allow for contraction when the temp. falls. If the wires are stretched tightly on a hot day, then during a cold day as the wires would contract, a considerable tension will be produced. This tension can even break the wires.

[**Note** : For the same reason : (*i*) Gaps are left in the roadway of a bridge ; (*ii*) Gaps are left in concrete roads ; (*iii*) Hot water pipes or oil pipes in deserts are provided with loops here and there ; (*iv*) One end of a metal bridge is placed on rollers so that it can move when it expands or contracts.]

18. *Whenever a metallic wire is to be fused in glass, it is of platinum. Why ?*

Ans. Platinum and glass have almost *equal coefficients of expansion.* Hence their joint will neither crack nor leave a cavity for air or any other fluid to enter when heated or cooled. If some other metal is taken, the joint will either fracture or become loose on account of unequal expansions or contractions when the temp. of the joint is raised or decreased.

[**Note** : These days, platinum has been replaced by an alloy called **Dumet** consisting of iron and nickel.]

19. *Two glass tumblers have stuck together into each other. How will you separate them by the use of cold water ?*

Ans. When we are given cold water, we shall *pour it in the inner tumbler* which will coutract while the outer one will remain at room temp. This will result in loosening the grip of the outer tumbler on the inner one and thus they can be easily separated.

20. *Two glass tumblers have stuck together into each other. How will you separate them by the use of hot water ?*

Ans. When we are given hot water, we shall dip the outer tumbler, nearly upto its brim, in hot water. This will expand the outer tumbler while the inner one will remain at room temp. As this creates some space between the two tumblers, they can now be easily separated.

21. *Would a single large sheet of copper be satisfactory to cover one half of a roof on a house ?*

Ans. *No* ; its expansion would be so great that it would buckle and pull the tacks loose. [That is why concrete roads are marked off into blocks.]

22. *A pendulum clock is regulated in winter. Will it gain or lose time in summer ? And why ?*

Ans. Whenever a clock is regulated, its time period is made 2 seconds at that time. And the time period of a pendulum is given by the relation $t=2\pi\sqrt{l/g}$.

In *summer*, the temp. is higher than that in winter. Therefore, on account of expansion, the length l of the pendulum increases which increases the time period t of the pendulum. Suppose it becomes 2·01 seconds. Since the mechanism of the clock is such that it records only 2 seconds for one vibration, therefore, although here the time elapsed is 2·01 seconds, but the clock-hand registers only 2 seconds. That is, in every 2·01 seconds, the clock *loses* $2{\cdot}01-2=0{\cdot}01$ second. Hence the clock will run *slower* in summer.

[**Note** : Similary, we can show that *a clock regulated in summer will gain time or run faster in winter.*]

23. (*a*) *What do you mean by a compensated* pendulum ? (b) How is it done ? (c) Can you somehow do without it ?*

Ans. (a) : A compensated pendulum is that in which an arrangement is made to keep its effective length constant even when temp. changes, so that its time period can remain constant. Such a clock will neither gain nor lose time with the change of temp. Thus it will always give correct time

(b) : The simplest way of doing this is by using strips or rods of two different metals in its construction in such a way that the rods of one metal contract (or expand) in one direction while the rods of second metal contract (or expand) in the opposite direction by the same amount. Thus the C.G. of the pendulum remains at a fixed position. Thus the effective length of the pendulum is kept constant.

(c) : We can do without a compensated pendulum if we use ordinary pendulums made of *invar*. Invar is an alloy of nickel and steel, and its coefficient of linear evpansion is 0·0000009/°*C* which is so small that the length of an invar pendulum will hardly change on account of seasonal changes in temp.

24. *Why should a liquid have two types of expansion - apparent and real ?*

Ans. Whenever we have to heat a liquid, it is to be taken in a vessel. Evidently, when this liquid is heated up, the vessel also expands. If we do not take into consideration the expansion of the vessel, we get somewhat decreased expansion of the liquid, called its *apparent* expansion. If we take into consideration the expansion of the vessel, we get the correct expansion of the liquid, known as its *real* expansion. These two expansions of a liquid are related to each other through the expansion of the vessel.

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*All solids expand when heated ; in some cases the expansion can be made to serve useful purpose while in others it is a nuisance for which allowance or compensation has to be made.

25. *A solid floats in a liquid so that it is just totally immersed. What happens when the system is heated so that the temps. of the solid and of the liquid are always equal ?*

Ans. Liquids generally expand more* than solids for the same rise of temp. As the temp. increases, the wt. of liquid of volume equal to that of the solid decreases *i.e.* the upthrust on the solid decreases. As a result the solid starts *sinking* down.

26. *In Dulong and Petit's Method, although its one limb contracts and other limb expands and we do not take into consideration this contraction or expansion, and yet we calculate the coefficient of real expansion of a liquid. How will you justify this anomaly ?*

Ans. The reason is that in this method we do not use thrust of the liquid in the two arms. We equate the balancing pressures and we know that the pressure of a liquid (or gas) column is independent of the area of cross-section of the tube.

27. *Why do the aquatic animals live safely in lakes and ponds even in the severest winter in cold countries when the temp. falls below the freezing point ?*

Ans. When water is cooled, its contraction continues up to a temp. of 4°C where its density is maximum. Further cooling is accompanied by expansion until its freezing temp. of 0°C is reached. This temp. of 0°C is for the water on the surface while it is still 4°C at the bottom. Since the temp. of air is below 0°C, it will be the water on the surface which will freeze into ice while the water at the bottom will remain at 4°C. And since ice is a bad conductor of heat, so the layer of ice on the surface will not allow the 4°C water at the bottom to lose its heat. This helps the aquatic animals to continue to live in 4°C water in the severest winter.

28. *Why do ponds and lakes freeze around the edges before they do in the middle ?*

Ans. Because the shallow water will be cooled to 4°C at the bottom more quickly than can be the deeper water.

29. *How can you remove a small dent from a ping-pong ball ?*

Ans. Gases expand much more than solids when heated. The expansion of the ball will be nearly negligible† when heated above a flame and hence the pressure of the inside air will increase. Since this pressure acts uniformly on all sides, the deformed ball must return to the spherical shape. Thus the dent will disappear. Now the ball can be cooled to the room temp.

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*That is why a mercury thermometer with only its bulb in hot water will read less than when the stem of the thermometer is lowered deeper into the same hot water.

†That is why we do not talk of apparent expansion of a gas although it is also contained in a vessel.

30. *Two identical vessels filled with hydrogen are connected by a tube in which there is a small column of mercury (Fig. 2-2). In one vessel the hydrogen is at 0°C and in the other at 20°C. Will the column of mercury be displaced if both vessels are heated through 10°C ?*

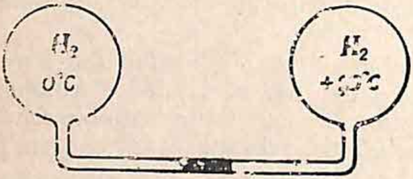

Fig. 2-2

Ans. When both the vessels are heated through 10°C, then to calculate the final pressure

(*i*) P_1 for H_2 at $0°C$, we have

$$\frac{P.V}{273}=\frac{P_1.V}{273+10}$$

or $$P_1=\frac{283}{273}\times P=1{\cdot}04\,P$$

(*ii*) P_2 for H_2 at $20°C$, we have

$$\frac{P.V}{273+20}=\frac{P_2.V}{273+30} \quad \text{or} \quad P_2=\frac{303}{293}\times P=1{\cdot}034\,P$$

Since $P_2 < P_1$, so the column of mercury will shift towards the vessel in which the hydrogen was at first at $20°C$.

31. *Human body can stand hot air without being burnt but hot water at the same temp. is dangerous. Why ?*

Ans. Total heat contained by a body depends upon its mass, sp. heat and temp. For equal volumes, the mass of water is far greater (nearly 775 times) than that of air. Also, the sp. heat of water is much greater (nearly 6 times) than that of air. Hence, when equal volumes of water and air cool down through the same range of temp. while imparting heat to a human body, water gives out much more heat than is done by air. Hence the difference in their effects.

32. *Why is water used in hot water bottles for fomentation ?*

Ans. For fomentation that substance is to be used which will give out more heat when its given mass is cooled through a given range of temp. This substance will also absorb more heat on warming. Since this heat depends upon the mass, sp. heat and range of temp. of a substance, therefore, the most suitable substance for fomentation will be the one having maximum sp. heat, and of all solids and liquids, water has the *highest sp. heat*. Hence the choice of water is most suitable.

[**Note** : For the same reason, *hot water is used in pipes for heating rooms in cold countries*]

33. *Why does the climate of the places near the sea remain moderate throughout the year ?*

Ans. We know that sp. heat of water is very high and so it requires more heat to change its temp. through a given range. During the day when the sun shines, the earth becomes hotter than the water of the sea. Hence the air in contact with the earth becomes hotter and lighter and so it rises up. As it creates a partial vacuum on this part of the earth, so to occupy this place moist and cool air from the sea moves towards the earth. This is known as the *sea-breeze.*

At night, the earth cools down much quicker than the sea-water. Evidently, the air in contact with sea-water will rise up, resulting in the motion of cool air from earth towards the sea. This is known as the *land-breeze.*

It is on account of these land- and sea-breezes that the climate near the sea remains moderate.

[**Note** : Moderate climate is ideal for fruit growing. That is why fruit-growing regions are commonly located near large tracks of water.]

34. *A cycle party going on picnic to a beach finds the wind opposing it in the morning. After night-fall when the party returns, it again finds the wind opposing it. How and why should this happen ?*

Ans. First explain as in Q. 33 above how sea-breeze and land-breeze are caused.

In the morning, the party encounters the sea-breeze and after nightfall it meets the land breeze.

35. *For a gas, why is its* $s_p > s_v$?

Ans. Sp. heat of a substance is equal to the number of calories of heat required to raise the temp. of 1 gm of substance by 1°C.

In the case of s_v, when we heat the given (1 = gm.) gas the pressure of the gas increases bus its volume remains the same. Therefore no external work is done by the gas.

But in the case of s_p, when we heat the given (=1 gm.) gas, its pressure remains constant but its volume increases. As the gas expands against the external atmospheric pressure, it has to do *some work.* Moreover, the gas particles are to be drawn further apart against their mutual force of universal gravitation. For these, additional heat is required besides the one that raises the temp. of the gas by 1°C.

Hence $s_p > s_v$.

[**Note** : Since an expanding gas has to do some work for its expansion, that is why (*i*) the *air escaping from a puncture in a tyre is perceptibly colder than its surroundings,* (*ii*) *as we go up in the atmosphere, the temp. of air goes on decreasing as the compressed air at the bottom expands upward.*]

36. *Can sp. heat be negative ?*

Ans. *Yes* ; sp. heat of saturated vapours is negative. If we want to raise the temp. of 1 gm. of saturated vapours, some heat has to be withdrawn to keep them saturated.

37. *Why does ice appear colder than the ice-cold water although both are at the same temp. of 0°C ?*

Ans. It is because of the latent heat of fusion of ice. When ice melts into water at 0°*C*, its each gm. requires 80 calories of heat which it absorbs from our hand. Further absorption of heat will remain same for both. It is this additional requirement of 80 calories/gm. for ice which makes the ice to appear colder than the ice-cold water.

38. *Why is the steam at 100°C more dangerous than water at 100°C ?*

Ans. It is due to the fact that steam at 100°*C* has more quantity of heat due to its L. H. than water at 100°*C*, by an amount of 536 cal./gm.

It is on account of this additional heat of 536 cal./gm. that the steam causes more severe burns than water at the same temp.

39. *Why does ice melt but wax harden when subjected to pressure ?*

Ans. We know from the *laws of fusion* that, by the increase of pressure the melting point of substances which contract on melting *e.g.* ice, is lowered *i.e.* it melts and of substances which expand on melting *e.g.* wax, is raised *i.e.* it hardens. Hence the reason.

[**Note** : Earth comes in the category of wax. Although the temp. of the interior of the earth is higher than the melting point of all known substances, yet the interior of the earth is solid because its interior is subjected to a very high pressure on account of its thick crust and hence the earth hardens]

40. *Why should ice-cubes coming from a fridge have bumps ?*

Ans. Ice is lighter than water. When 1 c.c. of water freezes, it becomes 1·091 c.c. of ice. Moreover, freezing starts from the surface of water. Evidently when the water starts freezing in its metallic container (divided into many parts), placed inside a fridge, ice takes up more room than water and hence its ice-cubes must have bumps.

41. *What makes the ice cube roll around as it melts in hot water ?*

Ans. As ice in hot water melts away on the bottom, it becomes top heavy and rolls over to come again to a position of stable equilibrium.

42. *Why do restaurants sometimes use ice cubes with holes in them ?*

Ans. Liquid enters in these holes also and comes in contact with greater surface of an ice-cube which melts faster, making a drink get colder more quickly.

43. *Dal or meat can be cooked in about 15 minutes in a pressure cooker while they take about an hour when cooked in an ordinary way. Why ? Explain the scientific principle involved.*

Ans. The boiling point of water, at a place, varies with the pressure on its surface. It is increased by the increase of pressure and *vice versa*. In cooking dal or meat, if the b.p. is higher, more heat is supplied resulting in the cooking of the articles in shorter time.

Steam does not escape out but remains inside the pressure cooker, thus increasing the internal pressure on the surface of boiling water. The water will thus boil at a higher temp. and will contain more heat. This heat in turn will be supplied to the dal and it will cook the dal in a shorter time.

44. *Why does not ice readily melt when salt is sprinkled on it ?*

Ans. The temp. of ice is lowered from $0°C$ to $-22{\cdot}5°C$ on sprinkling salt over it and it does not therefore melt rapidly.

45. *The temp. of $0°C$ is both the temp. at which ice melts and that at which water freezes. What will happen if we put a piece of ice at temp. $0°C$ into a vessel containing water also at $0°C$?*

Ans. Ice melts at $0°C$ only if the required amount of 80 calories of heat per gm. of ice be imparted to it, while water will freeze only if the same amount of heat is taken out from it. Therefore, if the vessel is not heated or cooled from outside, the water will not freeze and the ice will not melt. It will remain a mixture of ice and water at $0°C$.

46. *What happens to the temp. of the atmosphere when it is raining or snowing ? Does it fall or rise ? And why ?*

Ans. When it is raining or snowing, the temp. of the atmosphere *rises*. When we heat ice, it melts and changes into water. When water is heated, it changes into vapour or gaseous form. In the reverse process, heat will be evolved. Hence when it is raining, the water vapours of clouds condense into water drops, giving out their L.H. of vaporisation. When it is snowing, the clouds directly freeze to the solid state and give out their L.H. of vaporisation as well as L.H. of fusion. Evidently, the temp. of the atmosphere will rise.

47. *How is the formation of snow-balls possible ?*

Ans. Although the snow falls like cotton flakes, yet we can form solid snowballs by compressing snow in our hand with our fingers. Since ice (or snow) contracts on melting, the increase of pressure lowers the melting point of ice or freezing point of water. When snow is pressed by fingers, a little of snow melts* and water so formed enters inside the snow. This water will be below $0°C$ and it will refreeze when the pressure is released *i.e.* when the snow-ball is thrown. Thus we play with solid and hard snowballs when throwing them on one another.

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*Ice at a temp. close to $0°C$, under a skate melts due to high pressure caused by the narrow edge of the skate. So the movement of a skate, in effect, is over a film of water. At very low temps. higher frition is experienced since the pressure may be insufficient to cause melting of ice and hence skating will be impossible.

48. *Wishing to cool a saucepan of water to room temp. as quickly as possible, a housewife puts it on ice. Is this the right way ?*

Ans. *No.* This is not the right way. As the cooling agent is put underneath, the heavier water at the lower temp. stays at the bottom of the saucepan and hence there will be no stirring effect in the absence of convection currents. Moreover, water is a bad conductor of heat and therefore cooling will take a very long time. To cool water more quickly, the ice should be put on top.

49. *Why does a cloud often appear to rise from a block of ice as from boiling water ?*

Ans. Air contains enough moisture all the time. Water vapours coming in contact with ice are cooled and they condense in the form of mist. As the cooling effect of ice gradually proceeds upward, the increasing height of mist gives an impression as if the ice is steaming.

[**Note** : Similarly, an iceberg is often surrounded by fog.]

50. *Why is our exhaled breath more visible in cold than in hot weather ?*

Ans. Ordinarily water vapours, like air, are transparent and invisible. They are only seen as white vapours when tiny particles of water have been produced from the exhaled breath by its being cooled below its dew point. On a cold day, this cooling is much greater than when it is hot weather, and hence the difference.

51. *One often sees a housewife who turns up the flame under a saucepan in order to make the contents boil faster. Is this the right thing to do ?*

Ans. If the temp. of all the water has already reached 100°*C*, it will not rise until all the water has turned into steam. Therefore, it is quite useless to turn up the flame. The heat applied should be just enough to maintain boiling in the whole saucepan and to compensate the loss of heat.

52. *The station-platform tea is much hotter than the one ordinarily prepared at home. Why ?*

Ans. Impurities raise the boiling point of a liquid, that is why a sugar solution boils at a temp. much higher than 100°*C*. The station-platform tea is a mixture of water, milk and sugar boiled together. But in the home we use boiled water only for the preparation of tea in which tea, milk and sugar are added later on.

53. *Can water be made to boil without heating it ? Can water boil at 0°C ? If yes, how ?*

Ans. *Yes,* if it is put under the mouth of an air pump and the air be pumped out. For any liquid, its boiling point is lowered when the pressure acting on it is decreased. Water will boil at room temp. if the pressure of air above it falls to about 15 mm. of mercury. If the pressure is lowered further, water can boil at 0°*C* also.

[**Note** : (*i*) When water boils at a temp. lower than its boiling point because the pressure acting on it has been reduced and no external heat is being supplied, *it becomes colder as it boils* as it takes from itself the required L.H. of vaporisation.

(*ii*) *Superheating* occurs when water is free from dust and the walls of the vessel are clean and smooth. In the absence of the vaporisation nuclei, boiling does not occur, even though the temp. may rise above the boiling point. To obtain boiling, small pieces of porous pot are generally placed in the liquid container.

(*iii*) L.H. at the critical temp. and above is zero.]

54. *Why is heat necessary for the change of state ?*

Ans. According to the Kinetic Theory of Matter, the matter is composed of molecules which attract one another. In solids, these molecules are quite near to each other, in liquids they are not so near while in gases they are farther apart. Thus molecular attraction is maximum in case of solids and minimum for gases. When we convert a solid into a liquid or a liquid into a gas, work has to be done in separating the molecules against this force of attraction and the heat given does this work.

55. *How does L.H. of steam depend upon boiling point of water ?*

Ans. L.H. of steam increases by decrease in boiling point of water. For example,

at $100°C$, $L=536$ cal./gm.
at $40°C$, $L=588$ cal./gm.
at $0°C$, $L=606$ cal./gm. for steam.

[**Note** : It might be remembered that the boiling point decreases with decrease in pressure. Hence this L.H. depends upon pressure also.]

56. *What will happen to the steam if its passage is continued in the water which has reached a temp. of 100°C ?*

Ans. Since the water has attained the temp. of steam, it cannot condense steam any more and hence the $100°C$ steam will start bubbling out of water without losing any heat to water.

57. *A cylinder is provided with an air-tight piston and contains enough water at its bottom at 20°C. What happens when (i) temp. is raised to 25°C without changing the position of the piston, (ii) temp. is lowered to 15°C without changing the position of the piston, (iii) the piston is raised up when temp. is kept constant, and (iv) the piston is pushed inward without changing the temp. ?*

Ans. Since water is present in the cylinder, the space under the piston contains saturated water vapours at $20°C$.

(**i**) : Because the saturation vapour pressure increases with the increase of temp. and enough water is present in the cylinder to keep the space saturated, therefore the saturation vapour pressure *increases* when temp. is raised to 25°*C*. Some water will change into vapour and the level of water will fall slightly.

(ii) : In this case, since the temp. is lowered to 15°*C*, therefore the saturation vapour pressure *decreases*. The excess vapours will condense and the level of water goes up slightly.

(iii) : When volume is increased at constant temp., it will require more vapours to be formed to saturate the increased volume. Since the saturated vapours do not obey Boyle's Law and saturation vapour pressure is independent of the volume of the empty space, therefore the pressure remains *unchanged*.

[If there would have been no water in the cylinder and the vapours would have been just saturated, then the increase in volume will result in decrease of pressure because vapours become unsaturated.]

(iv) : When volume is decreased at constant temp., extra vapours will condense, the vapours will still remain saturated at the same temp. and hence its pressure will remain *unchanged*.

58. *What determines the dryness and dampness of air—A.H. or R.H.? Why?*

Ans. It is R.H. and not A.H. which determines the dryness or dampness of air. Hot air in summer is much less moist than cold air in winter but we find that at the same temp. one cubic metre of air contains less moisture in winter and more in summer. Thus A.H. does not give a correct judgment about the dryness or dampness of air.

But air requires much more vapours to saturate it in summer than in winter. This gives greater R H. in winter and less in summer. Hence the dryness or dampness of air is correctly judged by Relative Humidity and not by Absolute Humidity.

59. *In a room at 20°C temp., a R.H. of 40% is taken. At the same time, R.H. outside, where temp. is 0°C, is found to be 80%. If an outside window in the room be opened, which way will the water vapour move?*

Ans. Water-vapour will pass *from outside* into the room because the vapour pressure or density of water vapour is greater at R.H. of 40% and a temp. of 20°*C* than at a temp. of 0°*C* and R.H. of 80%.

60. *Why is dew not formed on a cloudy night?*

Ans. For dew formation, there should be a continuous fall of temp. at night. But *cloudy* nights are warmer than the clear ones.* The reason is that on clear nights, heat of the earth is radiated away far into space, while on cloudy nights much of this radiation is reflected back to earth by these clouds and hence the temp. of air does not fall down.

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*A thick layer of smoke serves the same purpose. That is why the bad effects of night-frosts to fruit-growing places are sometimes reduced by covering the orchards with a thick layer of smoke.

61. *Why is dew not formed on a windy night ?*

Ans. For dew formation, the saturated water vapours from the atmosphere should stay in contact with a cold surface to give some time for condensation. These vapours will be pushed away constantly if a wind is blowing. Hence the result.

62. *How is cooling caused by evaporation ?*

Ans. (i) : A good amount of heat is required for vaporizing a liquid. When a liquid changes into vapours, its L.H. of vaporisation is supplied by the liquid itself. As the liquid loses heat, its temp. falls down.

Ans. (ii) : According to the *Kinetic Theory of Matter*, only the fast moving molecules are able to escape from the liquid surface and become vapour (since the atmospheric pressure is opposing this process). Because the liquid is constantly losing the faster (*i.e.* higher K.E. or higher temp.) molecules while the slow moving molecules are left behind, hence the temp. of liquid falls on evaporation.

63. *Why is summer heat often oppressive before a shower ?* **Or** *why is it difficult to keep cool in summer when R.H. is above 90% ?*

Ans. Before a shower, since *relative humidity* is very high, the air is nearly saturated with water vapours. This will make the rate of evaporation of sweat almost nil. Hence no cooling is caused. That is why the summer heat becomes oppressive and unbearable before a shower.

[**Note** : It is also on account of high R.H. that *a hot day in Calcutta causes far greater discomfort than an equally hot day in Delhi.*]

64. *Water placed in the earthen pitcher is colder than the water kept in a metal container. Why ?*

Ans. There are number of pores in an earthen pitcher. Water continuously comes out through them and evaporates—resulting in the cooling of water. It is not possible in the case of a metal container, as there are no pores in it.

65. *Why does a dog hang out his tongue in hot weather ?*

Ans. The dog cannot lose heat, as we do, by perspiring on account of comparatively less pores on its body. The dog hangs out his tongue so that evaporation occurs there. We know evaporation causes cooling. Hence he does so, in order to cool himself in hot weather.

66. *During a hot season, why does fanning give a feeling of comfort ?*

Ans. During a hot season, perspiration comes out from our body. By fanning, it evaporates and causes cooling to the body. Also, the fanning puts the air in motion which increases the rate of evaporation and also lowers the temp. of the surrounding air, giving us a feeling of comfort.

67. *A fan cools you off in the summer. A fan makes an ice cube melt faster. How?*

Ans. For first part, see Q 66 above.

As an ice-cube melts, the air around it becomes cooler. A fan blows more warm air past the ice, making it melt faster.

68. *In the winter you blow on your hand to make them warm. But when you burn your finger you blow on it to cool it off. Why?*

Ans. If you breathe out slowly on your hands, your breath will feel hot since your hands are at a lower temp.

It cools your finger by evaporating the moisture that comes along the breath.

69. *Why do wet feet or clothes give us a bad cold?*

Ans. The water in clothes in contact with our body will evaporate and it will take heat from our body so that its temp is lowered below 37°*C*. Thus the body is cooled, resulting in injuring of our health.

70. *Why is it difficult to "catch a chill" by getting wet with sea-water?*

Ans. It is because the salt retards the evaporation of water and so the heat of body is lost slowly. The sea-salt also acts as a stimulant. It therefore prevents the sensation of cold.

71. *Why is the well-water warmer in winter and colder in summer?*

Ans. It is because the earth is a bad conductor of heat. It does not conduct the external heat or cold to its lower layers. Hence inside earth, the temp. of water remains constant. If earth were a good conductor of heat, springs would be dried up in summer and frozen in winter, destroying soon all the vegetation.

72. *Why are loose clothes warmer than the close fitting ones?*

Ans. Air is a bad conductor of heat. More air is enclosed in the loose clothes than in the tight-fittings. So this warm air will not conduct heat from our body to outside air and the conclusion follows.

[**Note** : (*i*) *Fur-coat* is not a source of heat ; it does not have any warmth of its own to give. It merely prevents our body from shedding its own warmth.

(*ii*) At low pressures, the thermal conductivity of a gas varies directly with the pressure.]

73. *Why do newly ironed sheets and pyjamas feel colder at bed time?*

Ans. Smooth things feel colder than rough ones. When things are smooth, much more of their surface touches and much less (bad conductor) air is trapped. So the part of the body in contact with newly ironed sheets and pyjamas loses more heat by conduction. Hence this observation.

74. *Why should we not feel warm without clothing if air is a bad conductor of heat ?*

Ans. We know that air is always in motion. It takes heat from our body by convection and makes us feel cold. If the air remained motionless, it would become warmed to the temp. of our body.

75. *What do you understand by the term 'air-conditioning' ?*

Ans. Air-conditioning is a process by which we keep air under such conditions which afford maximum comfort to the human body. For this purpose, we have to control four factors of air :

(*i*) *Temp. of Air* (from 18° to 32°C). Higher temp. causes uneasiness and lower temp. causes shivering.

(*ii*) *Relative Humidity* (from 60 to 65%). Higher R.H. will decrease the rate of evaporation—resulting in giddiness. On the other hand, lower R H. will produce rapid evaporation causing shivering in the body.

(*iii*) *Convection Currents* (velocity of air 7·5 to 22·5 metres/minute). This will replace about 25% of room air by fresh air. Lower velocity will increase the CO_2 content in the room and higher velocity will create a draught which will create further complications in the control of temp. and R.H.

(*iv*) *Purity of Air*—as nobody can withstand a bad smell for long time.

76. *How will you prove that water is a bad conductor of heat ?*

Ans. In a glass test-tube, put a small piece of ice and thrust a twisted wire-gauze in it so that the ice does not come to the top when 0°C water is filled in the tube (Fig. 2-3).

To avoid convention currents, heat the tube near the top. Ice will remain unmelted for a long time even after the water at the top continues to boil.

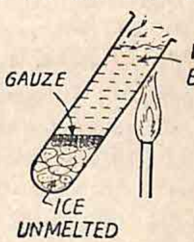

Fig. 2-3

77. *How does snow protect plants ?*

Ans. Snow is an insulator *i.e.* a bad conductor of heat. It traps the heat of the plants and stops the effect of frost from reaching the plants.

78. *How does fat help in keeping the body hot ?*

Ans. Fat is a good insulator and so the hot body (on account of internal heat produced by food) does not cool down as quickly as a thin body. It is advantageous in winter. But in summer, a thin body keeps itself much cooler than the fat one.

[**Note** : *Whales, seals, walruses and penguins* have very thick layers of fat that keep them warm in Arctic waters. *Channel swimmers* cover their bodies with thick layers of grease to keep out the cold. *A camel has all his fat in one place so that his body keeps cool.*]

79. *How does your face show whether you are feeling cold or hot ?*

Ans. When you are hot, your face becomes very red. This is caused by the blood rushing to your skin to get cool.

When you are cold, you go blue. Then, the blood rushes away from your skin to keep itself warm.

[**Note** : When you shiver, some of your muscles move quickly to make heat.]

80. *Why is a sensation of cold produced when the hands are plunged into a basin of cold water, even if the temp. of the water is the same as that of the air in the room ?*

Ans. Water, though a poor conductor of heat, is a better conductor of heat than air. Therefore it draws off our bodily heat through our hands more rapidly than air ; thus it feels colder.

81. *Why is a metal spoon often left in a saucepan by cooks ?*

Ans. It is to slow down the process of boiling. Because the metal spoon, being a good conductor of heat, carries off heat from the water—as a consequence of which the water takes longer to boil.

82. *Why are woollen clothes warmer than cotton ones ?*

Ans. Wool is a poor conductor of heat and so is cotton. But a woollen cloth contains a much larger layer of dry air in it than a cotton one.

Since air is a poor conductor of heat, it does not allow the bodily heat to escape nor allows the external cold to come in. Moreover, the rough surface of woollen clothes absorbs more and reflects less heat falling on it while cotton ones behave just the opposite.

[**Note** : In order to enclose a lot of air :

(*i*) *in winter, birds sit with their wings spread out* to protect themselves from the outside cold ;

(*ii*) the new quilts are warmer than the old ones ;

(*iii*) the double windows in a room in cold countries save fuel ;

(*iv*) furs are warm, and they are warmer still when worn with the skin outside and fur inside because the movement of the air among the fur is greatly impeded.]

83. *Why do Eskimos make double-walled houses of snow ?*

Ans. Eskimos live in polar regions where the atmospheric temp. is much below 0°*C*. The space between the two walls of their snow-houses entraps air which is a poor conductor of heat. This entrapped air does not allow the internal heat of the house to escape and thus Eskimos can live comfortably inside.

[**Note** : Workmen around furnaces wear woollen clothing in summer because wool is a good insulator and keeps away the heat.]

84. *A jar containing cloudy water is left overnight on the window ledge. By morning, cloudiness remains only on the side of the jar turned towards the room. At what time of the year is the experiment performed ?*

Ans. When a jar is heated non-uniformly, convection currents are constantly at work in it and at the bottom they act from the cold side towards the warm side. These currents transfer the sediments on the bottom towards the warmer side. In winter, the side turned towards the room is plainly warmer than that turned towards the window. Therefore, the experiment was performed in *winter*.

85. *Why do firemen wear helmets made of brass polished from outside ?*

Ans. Polished surfaces are bad absorbers and good reflectors of heat. Consequently, during the fire-extinguishing operation, the polished brass helmet will absorb very little of heat and will reflect most of the heat of the fire.

86. *Why are white dresses generally worn in summer time ?*

Ans. Because a white surface is a bad absorber of heat and throws off most of the heat of sun's rays by reflection. Hence they do not convey much heat to our bodies and are therefore more comfortable to be worn in summer.

[**Note** : Similarly we can answer : "*Why are the buildings whitewashed or painted white in hot countries*"?]

87. *Why is a new kettle blackened at the bottom before use ?*

Ans. Because a black surface absorbs the heat very quickly from the fire and the metal of the vessel conducts it to the liquid in it.

88. *Is it useful to use a black umbrella and why ?*

Ans. *No.* A black umbrella will absorb all the radiations incident on it from the sun and radiate them towards us. A white umbrella will be a poor absorber and hence a poor radiator and will protect us better from the sun.

89. *One bulb of two identical thermometers is coated with lamp black and the other with silver. Compare their readings when exposed (i) on a clear night (ii) in the sun.*

Ans. Black body is regarded as a good absorber as well as a good radiator of heat.

(**i**) On a clear night, the thermometer coated with lamp black will radiate more heat and will read less than the other.

(**ii**) In the sun, the thermometer coated with lamp black will absorb more heat and will read more than the other.

[**Note** : Because rough surfaces absorb (as well as radiate) more heat, that is why (*i*) untrodden snow on the footpath melts sooner than the trodden snow beside it ;

(*ii*) the dirty snow melts faster than the clean snow ; and

(*iii*) cylinders of the engine of a motor bicycle are rough and covered with fins.]

90. *Is it advisable to use polished tea-pot of silver ?*

Ans. There is *no harm* in it. Since polished surfaces radiate less heat, so the polished tea pot of silver will be able to retain the tea at the same temp. for a long time.

[**Note** : For the same reason, we use *polished calorimeters* to decrease the loss of heat due to radiation but it is not good to keep stoves highly polished if you want to avoid their bursting.]

91. *Why does a black spot on a platinum foil appear darker than the platinum at low temp. ?*

Ans. *At lower temp.*, the spot appears black because it absorbs most (and *reflects least*) of the light incident upon it. The platinum foil appears brighter by contrast as it reflects most of the light falling upon it.

92. *Why does a black spot on a platinum foil appear brighter than the platinum at high temp. ?*

Ans. *At higher temp.*, the black spot appears brighter because the black spot, being a better absorber than platinum, is also a better radiator than platinum. Hence this result.

93. *Why does a thermos flask keep things hot or cold ?*

Ans. A thermos flask, with its double-walled space, *emptied of air*, avoids loss or gain of heat by conduction and convection (which require medium for their transmission). The heat of the contents can only escape by radiation, which is considerably reduced by silvering the glass walls. In the first instance, the outer silvered wall of the inner vessel radiates very little heat which in turn is reflected back to the inner vessel by the inner silvered wall of the outer vessel.

94. *Which thermos flasks are better, given the same height and capacity—ones of square or of circular cross-section ?*

Ans. That thermos flask will be better which loses less heat in a given time. Exchange of heat takes place between the flask and the surrounding atmosphere through the side walls and the ends of the flask. Since the height and the capacity are the same, the end areas will also be the same. But the surface area of the side walls is not the same ; *the surface area of the sides of the cylindrical one is less* than that of the square flask (it can also be shown with the help of mathematical calculations). Hence the thermos flask with the circular cross-section will lose less heat than that with the square cross-section and therefore it (one with *circular* cross-section) *is better.*

95. *Higher the chimney, stronger the draught. How ?*

Ans. When fire is burnt under a chimney, it requires a continuous supply of fresh air to get necessary oxygen from it. Less is the quantity of available oxygen, less complete is the combustion and hence more wastage of fuel. Greater is the quantity of oxygen available, fiercer the heat of the furnace. This needs faster convection currents whose velocity depends upon the difference in pressures of the column of hot air inside the chimney and that of a column of cold and denser air of equal height outside the chimney. Evidently, greater is the height of the chimney, greater is this difference in pressures—resulting in a stronger draught and a better fire.

[**Note** : (*i*) Bowler hats have small holes in the crown.

(*ii*) The gallery of a theatre is hotter than the pit.]

96. *Why is the freezing compartment inside a refrigerator placed at the top ?*

Ans. Hot air produces upward convection currents while cold air does it downwards. The air coming in contact with the freezing compartment becomes colder and heavier and therefore sinks downwards while the hot air from the bottom of the refrigerator moves upwards. This process is continued till the entire inner space of the refrigerator attains a constant temp. The whole process takes a very little time.

Air is a bad conductor of heat and cold air is heavy. If the freezing compartment is placed at the bottom of the refrigerator, hot air will stay at the top. By conduction, various layers, being counted upward, will take a long time to cool.

97. *Can you cool off your room by leaving the refrigerator door open ?*

Ans. *No.* A refrigerator only takes heat from its inside and releases it into the room. If the refrigerator door is left open, there would be no change in temp.

98. *The wall above a hot water radiator is much dirtier than the wall below it. Why is it so ?*

Ans. Dust and soot particles coming above the hot radiator are pushed upwards with a great velocity by the convection currents of air. Therefore, these particles start sticking to the ceiling. This process continues and hence the observation.

[**Note** : (*i*) Things are "browned" on the top-shelf of an oven. (*ii*) Radiators are usually placed under or near the windows in a room so that the air from the window helps to facilitate the distribution of heat]

99. *A glass of hot water is to be cooled as much as possible in 15 minutes. Which is better : to put a piece of ice in and then leave the water to cool for 15 minutes, or to leave the water to cool for 15 minutes and then put the same amount of ice in ?*

Ans. Rate of cooling of a hot body by radiation is directly proportional to the difference of the temps. of the body and its surrounding atmosphere. Greater is this difference of temps., faster will the cooling take place. Therefore, it is *better to allow the water to cool first* and then put the ice in.

100. *Which would you prefer—(a) to pour milk and then wait, or (b) to wait and then pour milk in the hot tea ? And why ?*

Ans. It will be better to pour milk and then wait. Here the difference of temps. between the hot tea and the atmosphere will be reduced and hence will decrease the rate of loss of heat, *i.e.* fall of temp. will be slower.

101. *Why does the temp. of water rise at the bottom of a water fall ?*

Ans. Since the water is at a height, it possesses potential energy. It is capable of doing work ($W=m.g.h$). When this water falls down, its P.E. is converted into K.E. which, in turn, on account of friction,* changes into heat by the relation ($W=J.H$). Evidently when this heat is absorbed by the water at the bottom of the waterfall, its temp. has to rise.

102. *Is the power of Bhakra hydro-electric station sufficient to raise the temp. of the water that passes through its turbines to boiling point ? Temp. of water in the river is 20°C.*

Ans. To heat each 1 gm. of water from $20°C$ to $100°C$, the amount of heat required $=1\times1\times(100-20)=80$ calories. Since one calorie is equivalent to $4{\cdot}2\times10^7$ ergs of work, so the job requires work $=80\times4{\cdot}2\times10^7$ ergs. Since it is the potential energy ($=m.g.h.$, here $m=1$ gm.) of the falling water itself which changes into heat, therefore, the minimum value of the required height of the falling water will be :

$$h=\frac{80\times4{\cdot}2\times10^7}{980}\text{ cm.}=34{\cdot}16\text{ km.}$$

But the height of falling water at Bhakra power station is only one-third of a kilometre. Hence the falling water cannot attain its boiling point.

103. *How many dead-centres are there in one cycle of a steam engine ? What is their importance ?*

Ans. In one cycle of the piston, there are *two* dead-centres when the sliding valve closes both the ports and cuts off the steam-supply to the piston chamber. Even in this position, the piston continues to move due to its own velocity and hence the steam under the piston expands which decreasas its pressure. Since the pressure is less than that of the steam entering now on the upper side of the piston, so the piston has to move downward (or inward).

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*A piece of steel becomes steadily hotter as a hole is drilled in it since the mechanical work being done against friction changes into heat.

In the absence of dead-centres, the pressure of steam on both sides of the piston will be same and hence the piston will not move at all. Thus the engine will fail to do any work.

104. *How does a petrol engine differ from a Diesel engine ?*

Ans. There are two main points of difference :

(1) Absence of sparking plug in a Diesel engine in which the temp. of compressed air at the end of compression stroke rises above the ignition temp. of the injected oil.

(2) In a petrol engine, there are two valves. But *a Diesel engine has three valves* (one for intake of air, second for intake of oil and third for the exhaust).

105. *What is the necessity of using a multi-cylinder (petrol) engine ?*

Ans. Out of four strokes, only one is the working stroke. This imparts to a vehicle an irregular and jerky motion, unless the fly-wheel is made very heavy (which is not possible in cars, aeroplanes, etc.) Therefore, for a smooth motion, we should use 4 (or multiple of 4) cylinders so that their working strokes take place *one after the other.*

1. An *atmometer* measures vaporisation.
2. A *bolometer* is an electrical device used for measuring small quantities of radiant heat.
3. A *cryophorus* is a freezing device (based on cooling caused by evaporation).
4. A *cryometer* measures lower temps.
5. A *hygrometer* measures relative humidity.
6. A *hypsometer* means a "height-measurer" with the help of boiling point of water.
7. A *katharometer* measures the thermal conductivity of gases.
8. A *potometer* measures the emission of vapours.
9. A *pyrometer* measures the expansion of bodies by heat.
10. A *radiometer* measures heat radiations.
11. A *thermograph* is a self-recording thermometer.
12. A *thermoscope* detects the presence of radiant heat.
13. A *thermostat* is a constant temp. device.

Part III—Light

Concise Light

1. **Nature of Light** : Light is the physical agency which produces in us the sensation of sight. Light has its origin in vibrating electrons. It is a form of radiant energy like heat and can be transformed into different forms of energy such as mechanical, chemical, electrical, etc. It is a wave-motion which travels with a speed of 186,000 miles or 3×10^{10} cm. per second. It can travel across empty space and is of the same nature as infra-red, ultra-violet and radio waves and X-rays, differing only in wave-length.

"Light is nature's fastest messenger" – *Einstein.*

An *optical medium* is a substance through which light can pass, *e.g.* air, water and glass. An *opaque* medium is that through which light cannot pass. It is called *transparent* when light can pass through it and *translucent* or semi-transparent when light is allowed to pass only partially through it.

Frosted bulbs are translucent. Formerly they were frosted on the outside ; now they are frosted on the inside since these are more easily kept clean.

2. **Rectilinear Propagation** : In a homogeneous medium, light travels in straight lines. A point source of light produces a sharp shadow. An extended source gives rise to a shadow which is in two parts—the inner part or *umbra* receives no light from the source while the outer part or *penumbra* receives light from some part of the source.

Phenomena of eclipses and working of a pin-hole camera also afford good examples in support of rectilinear propagation of light.

3. **Eclipses** : These are due to the shadow of one heavenly body falling on another. Whenever an opaque object comes in-between the source of light and screen, it cuts off a part of light rays falling on the screen, so that a shadow is formed. We know that the Earth moves around the Sun while the Moon moves around the Earth. When these three planets are in such a position that the Earth is in-between the Sun and the Moon, a portion of or all the sun rays shall be cut off so that either a part or whole of the Moon shall come in the shadow of the Earth and cannot be seen by us. This condition is said to be *lunar eclipse.* Since the lighted half of the moon must be facing the earth, the lunar eclipse occurs only when the moon is full.

If however the Moon comes in-between the Sun and the Earth, it shall form its shadow on the part of the Earth. People living in this part shall not be able to see a part or whole of the sun. Such a condition is called *solar eclipse.*

A *total solar eclipse* occurs when the Moon is at such a distance from the Earth that the apparent size of the Moon is bigger than the Sun. When the apparent size of the Moon is smaller than the Sun, an *annular eclipse* occurs.

4. Photometry. It is a branch of science of measuring light. Light is a measurable quantity. Just as electricity is regarded as a flow of electric charge, similarly light is regarded as a flow or flux of radiant energy.

(a) **Illuminating Power** (*of a source of light*) is the amount of light that falls per second normally on unit area of a surface held at a unit distance apart from the source. Its units are :

(*i*) *Candle Power* (C.P.) which is the illuminating power of an International Standard Candle made of sperm, weighing $\frac{1}{6}$ lb., $\frac{7}{8}$ inch in diameter and burning at the rate of 120 grains (=7·776 gm.) per hour.

(*ii*) *Candela* (which is 1/60th of the candle power) is defined as 1/60th of the radiation by one square centimetre of a surface of a full radiator (*i.e.* a black body) at the temp. of 2042°*A* of solidification of platinum.

The advantage of the candela as a primary standard is that it is dependent on temp. only whereas the flame standards are affected by external conditions.

(*iii*) *Lumen* which is equal to the quantity of light emitted per sec. per unit solid angle by a source of 1 C.P. [**1 C.P.** $=4\pi$ **lumens**].

(b) **Intensity of Illumination** (*of a surface receiving light*) is the amount of light received in a unit time by a unit area of the surface. It is maximum when light is incident normally on the surface. For oblique incidence, it obeys *cosine law.* Its units are :

(*i*) *Centimetre-Candle* (or *Phot*) which is the amount of light falling per second on 1 sq. cm. area of the inner surface of a sphere (for normal incidence) of 1 cm. radius on whose centre a standard candle burns as a source of 1 C.P.

(*ii*) *Metre-Candle* (or *Lux*) which is 1 lumen per square metre.

$$1 \text{ phot} = (100)^2 \text{ lux}$$

(*iii*) *Foot-Candle* which is 1 lumen/sq. foot and is equal to

$$\left(\frac{100}{12\times 2{\cdot}54}\right)^2 = 10{\cdot}764 \text{ lux}$$

(c) **Inverse Square Law** states that the intensity (I) of illumination produced by a point source of light is inversely proportional to the square of the distance (r) from it and is directly proportional to the power (L) of the source used. Thus

$$I = L/r^2$$

[**Note** : The inverse square law does not apply to the head lights of an automobile on account of the reflector.]

(**d**) Powers of light sources are compared by **photometers** whose working depends upon the location of a point where two given sources of light produce same intensity of illumination. Then

$$L_1/L_2=r_1^2/r_2^2$$

5. Laws of Reflection of Light : (*i*) The reflected ray, the normal and the incident ray lie in the same plane.

(*ii*) The angle of incidence is equal to the angle of reflection.

6. Real and Virtual Images : A *real* image is one through which the reflected/refracted rays actually pass, and hence a real image can be obtained on the screen.

A *virtual* image is one from which the reflected/refracted rays of light *appear* to diverge and hence cannot be projected on the screen.

7. Properties of Plane Mirrors : (*i*) When an image is formed by reflection on a plane mirror, it is a virtual image.

(*ii*) Two plane mirrors arranged at an angle produce a number of images of an object placed between them. At 60°, at 90°, at 150°, the number of images are five, three and two respectively. An infinite number of images are produced at 0° or when mirrors are kept parallel.

(*iii*) An image is always as far behind the mirror as the object is in front of it.

(*iv*) If the mirror is rotated about an axis when a ray of light falls on it, the angle turned through by the reflected ray is twice the angle turned by the mirror.

8. Laws of Refraction of light : (*i*) The incident ray, the refracted ray and the normal all lie in the same plane.

(*ii*) The ratio of the sine of angle of incidence to the sine of angle of refraction is a constant for the two given media, called the refractive index (μ) of the medium in which the refracted ray lies w. r. t. the medium in which the incident ray lies. This is known as **Snell's Law.** Also

$$\mu=\frac{\text{velocity of light in the medium of incident ray}}{\text{velocity of light in the medium of refracted ray}}=\frac{c}{v}$$

Note : (*a*) Refractive index has *no unit* since it is the ratio of two similar quantities.

(*b*) Refractive index of any substance w. r. t. air is never less than one.

(*c*) Optical denseness has nothing to do with the physical density of the medium.

9. Properties of Refractive Index : (*i*) It depends upon the medium in which light is travelling.

(*ii*) If ${}_a\mu_g$ is the refractive index from air to glass and ${}_g\mu_a$ is from glass to air, then,

$$ {}_a\mu_g = \frac{1}{{}_g\mu_a} \quad \text{or} \quad {}_a\mu_g \times {}_g\mu_a = 1 $$

Similarly $$ {}_b\mu_a \times {}_c\mu_b \times {}_a\mu_c = 1 $$

(*iii*) For a given pair of substances, the refractive index depends on the colour of light used.

10. Critical Angle and Total Internal Reflection : When a ray of light passes from a medium of higher refractive index to one of lower refractive index, the ray is bent away from the normal. If in this case the angle of incidence is increased until the angle of refraction is 90°, then this angle of incidence is called the *critical angle* (denoted by θ in Fig. 3-1). At angles of incidence greater than the critical angle, *total internal reflection* occurs and no light is refracted.

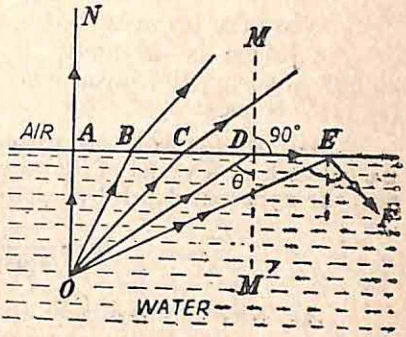

Fig. 3-1

Light can travel from one end of a hollow spiral pipe to the other end on account of total internal reflection.

11. Passage of Light through a Prism : When a ray of white light is passed through a prism :

(*i*) It is split up into colours, *i.e.* it is dispersed ;

(*ii*) Its path is bent, *i.e.* it is deviated on account of refraction at its two surfaces.

(*iii*) If i and e be the angles of incidence and emergence respectively, having r_1 and r_2 as their corresponding angles of refraction for a prism of angle A, then the angle of deviation (D) produced is given by

$$ A+D=i+e \quad \text{and} \quad A=r_1+r_2 $$

(*iv*) For a thin prism (whose angle is very small) of refractive index μ, we have

$$ D=A(\mu-1) $$

(*v*) By experiment it is found that the amount of deviation depends upon the angle of incidence and has a minimum value. For an equiangular prism (whose each angle is 60°), this minimum deviation occurs when the ray passes symmetrically through the prism.

12. Measurement of Refractive Index : (*i*) *By ray-tracing* : For solid block of material, use pins to trace the light. Measure the angles of incidence and refraction in one plane. Then use Snell's Law.

(*ii*) *By tracing rays through a prism* : Measure the angle of deviation for various angles of incidence and graphically find the angle of minimum deviation. If the angle of minimum deviation is D_m and angle of prism is A, then

$$\mu=\left(\sin\frac{A+D_m}{2}\right)\Big/\sin\frac{A}{2}$$

When the prism is used in the position of minimum deviation : (*a*) the image is brightest, (*b*) the object and the image are equidistant from the prism and hence magnification is unity, and (*c*) error is least.

(*iii*) *By the real and apparent depths method* : Place a transparent slab or a vessel of liquid over a mark on a sheet of paper and find the apparent depth by the method of no-parallax. Then

$$\mu=\frac{\text{real depth}}{\text{apparent depth}}$$

(*a*) When viewed from a rarer medium, the object placed in the denser medium appears raised up or nearer.

(*b*) When viewed from a denser medium, the object placed in the rarer medium appears further away.

13. Spherical Mirrors : (*i*) Distances are measured from the pole of the morror.

(*ii*) "Real—Positive ; Virtual—Negative" is the sign-convention used.

(*ii*) If u and v be the distances of the object (say of size$=O$) and the image (say of size$=I$) respectively from the pole of a spherical mirror of radius of curvature* r or of focal length f producing a magnification m, then

$$2f=r\,; \quad \frac{1}{f}=\frac{1}{v}+\frac{1}{u}\,;$$

and $$m=\frac{I}{O}=\frac{v}{u}=\frac{v-f}{f}=\frac{f}{u-f}$$

(*iv*) Note that f and r are +ve for a concave mirror and *—ve* for a convex mirror.

(*v*) Real images are inverted and virtual images are erect *w.r.t.* the object.

14. Lenses : Lens is a transparent medium bounded by two surfaces, out of which at least one is curved or spherical.

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* $\text{Curvature}=\frac{1}{\text{Radius of Curvature}}$

A lens is so-called because of its similarity in shape to a lentil seed.

(**a**) These are classified according to their action on parallel beam of light. Those which cause it to converge are called **converging** or **convex lenses** and are thicker at the middle than at the edges. Those causing it to diverge are called **diverging** or **concave lenses** and are thicker at the edges than in the middle.

(**b**) Distances are measured from the optical centre of the lens and any ray passing through the optical centre continues its straight path even after refraction and emergence.

(**c**) Here also, $\frac{1}{f}=\frac{1}{v}+\frac{1}{u}$

and $$m=\frac{I}{O}=\frac{v}{u}=\frac{v-f}{f}=\frac{f}{u-f}$$

(**d**) Note that f is +ve for a convex lens and −ve for a concave lens.

(**e**) If R_1 and R_2 be the radii of curvature of the two spherical surfaces of a lens having a medium of refractive index μ, then

$$\frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$$

(**f**) *By displacement method*, the focal length of a convex lens or of a combination behaving like a convex lens is given by

$$f=\frac{{}^2-d^2}{4.l}$$

where l is the distance between the object and image needles and d is the displacement of the lens for its two positions L_1 and L_2 (Fig. 3-2).

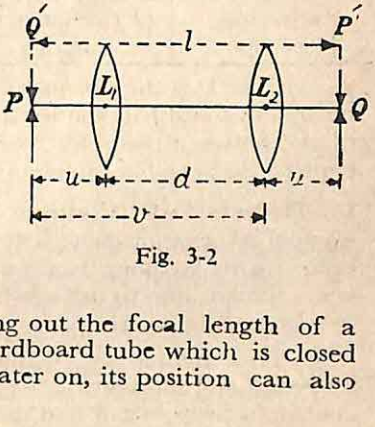

Fig. 3-2

This method can be used for finding out the focal length of a convex lens fitted somewhere across a cardboard tube which is closed at each end with pieces of flat glass. Later on, its position can also be calculated.

(**g**) For a lens, its power is given by

$$P_{dioptres}=\frac{1}{f_{metres}}$$

A convev lens has +ve power and a concave lens −ve power.

(**h**) The effective focal length (F) of two or more thin lenses (of focal lengths $f_1, f_2, \ldots$) in contact is given by

$$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}+\frac{1}{f_3}+\ldots$$

15. Optical Instruments :

Instrument	*Objective*	*Eye-piece*	*Tube-length* (L)	*M.P.*
Simple Microscope	One convex lens of short focus (f)		—	$1+\frac{D}{f}$
Compound Microscope	Short focus (f_0) convex lens	Short focus (f_e) convex lens	L	$\frac{L}{f_0}\left(1+\frac{D}{f_e}\right)$
Astronomical Telescope	Long focus (F) convex lens	Short focus (f) convex lens	$F+f$	$\frac{F}{f}$
Terrestrial Telescope	,, ,, ,, ,,	,, ,, ,, ,,	$F+f+4f'$	,,
Galilean Telescope	,, ,, ,, ,,	Short focus (f) concave lens	$F-f$	,,
Newton's Reflecting Telescope	Long focus (F) concave mirror	Short focus (f) convex lens	$<F$	,,

Here D is the distance of distinct vision and is 25 cm. for a normal eye and f' is the focal length of an additional convey lens placed between the objective and the eye-piece of a Terrestrial Telescope so that the final image is erect.

16. Defects of Vision : (*a*) **Myopia** or *Short-sightedness* : A myopic eye cannot see clearly the objects lying beyond a certain distance *i.e.* its far-point is not at infinity as it should be for a normal eye. This is due to the eye-ball being too elongated or the convex eye-lens being too thick.

To a myopic eye (*i*) human faces seem younger (as much as 20 years) and more attractive, (*ii*) at night, all bright objects assume enormous proportions and transform the world around into a chaotic jumble of shapeless bright patches and dark and misty silhoueties.

It is removed by using a *concave lens* whose focal length is equal to the distance of the far-point of the defective eye.

(*b*) **Hypermetropia** or *Long-sightedness* : In this case one cannot see the nearer objects clearly, but if the accommodation is normal, there is no difficulty about distant objects. It is due to either the eye-ball is short or the convex eye-lens is more divergent (being thin).

It is removed by using a *convex lens* of required focal length.

(*c*) **Presbyopia** (or *Loss of Accommodating Power due to old age*) : Such an eye can see neither very near objects nor very distant ones.

It is removed by using *bifocal lenses*, the lower halves of which are used for reading and the upper halves for distant vision.

(*d*) **Astigmatism** : Such an eye cannot form a point-image.

It is removed by using *cylindrical lens.*

Note : (*i*) It might be due to a twist in the optic nerves that the image visualized by the brain is erect though it is inverted on the retina.

(*ii*) Besides man, only the monkey (among the mammals) possesses a yellow spot on the retina.

17. Spectrum : Any ray after refraction suffers some amount of deviation, which varies with the refractive index of the light with respect to prism. Since white light consists of seven different colours and so each will have different value of ref. index w.r.t. prism and consequently each colour will suffer different deviation. Thus a white light after refraction through a prism splits up into different colours, *i.e.* voilet, indigo, blue, green, yellow, orange and red (VIBGYOR). Newton observed that violet was deviated the most and red the least. *This kind of decomposition or breaking-up of white light by a prism is called* **dispersion** *of light and the* **coloured band** *so formed is called the* **spectrum.**

Dispersion is shown by a **compound light** which consists of waves of different lengths. A **monochromatic light** contains only one wavelength and will not produce any spectrum. Ordinarily sodium light is taken as monochromatic, but really speaking sodium light also consists of two wavelengths (5890 and 5896 *A.U.*) with a small difference. Cadmium red line is truly monochromatic.

A **pure spectrum** is that where there is no overlapping of colours and the various component colours occupy distinct and separate positions. It is formed by using a spectrometer.

18. Chromatic Aberration in a lens is just on account of dispersion and a convex lens is to be combined with a concave lens (of proper focal length and dispersive power) to form an **achromatic lens**.

19. Kinds of Spectra : (*a*) *Emission Spectra* of substances which are heated to incandescence. These are of three types—continuous, line and band spectra.

(*b*) *Absorption Spectra* : a continuous spectrum, with certain characteristic lines absorbed from it by any substance or filter placed between the source and spectroscope-slit. These are of two types—line and band spectra.

Study of spectra has helped (*i*) in determining the nature of heavenly bodies, (*ii*) in gaining insight into the structure of matter, (*iii*) in analysing chemicals, (*iv*) in detecting impurities in food stuffs, chemicals, etc., (*v*) in detecting new elements (refer to the discovery of helium) and so on.

20. Electromagnetic Spectrum : It is a complete spectrum from secondary cosmic rays (wavelength$=10^{-7}$ to 10^{-3} *A.U.**) to Radio waves (wavelength$=0{\cdot}0004$ cm. to 40 km.).

Small amounts of ultra violet rays are good ; they help the skin to make vitamin D and this helps to keep you healthy.

It is mainly the ultra-violet rays in the sunlight that make plants grow The chlorophyll uses the ultra-violet rays to turn the carbon dioxide from the air, and water from the soil, into the food that plants need to make them grow.

21. According to De Broglie, a particle moving with a momentum p displays properties corresponding to a wave of wave-length

$$\lambda=h/p$$

where Plank's constant $h=6\ 625\times10^{-34}$ joule. sec.

22. Colour of Bodies : It is determined by the following factors :

(1) Amount of light (*i*) absorbed, (*ii*) reflected and (*iii*) transmitted ;

(2) Nature of incident light ; and

(3) Sensation produced in the eye by the mixture of colours received by the eye.

23. Types of Colours : (*a*) *Pure or Spectrum Colours* : Seven colours of a solar spectrum, to be remembered with the help of the word "vibgyor".

(*b*) *Primary Colours* : Those colours which are the basis of all other colours. These are *red*, *green* and *blue*.

(*c*) *Complimentary Colours* : Two colours are said to be complimentary to each other, which on being seen together give the sensation of white light.

(*d*) *Secondary Colours* : These are all other colours, except the three primary colours.

24. Laser : It is an abbreviation for "Light Amplification by Stimulated Emission of Radiation". It is an instrument to make a beam of light so bright that it can shine on planets. In it is a ruby crystal surrounded by a polished metal surface to act as a mirror A very bright light flashes upto the ruby crystal from something that looks like a flash bulb, and a very narrow, very brilliant beam flashes from the laser—so brilliant that it can reach the planets. By means of a laser, messages have been flashed to the astronauts landing on the moon.

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*X-ray wavelengths are measured in X-Units (or xu). This unit is equal to approximately 10^{-11} cm. 1 *A.U.*$=10^{-8}$ cm.

Objective Type Questions

CHAPTER XXII

RECTILINEAR PROPAGATION AND PHOTOMETRY

I. Complete the following sentences with suitable words or phrases :

(1) Light has its origin in.........

(2) Light travels in ......, and is a form of .... It travels with a velocity of ...... metres/sec.

(3) Moon is a ...... body while Sun is a ...... body.

(4) A transparent body is that through which ...... and an opaque body is that through which ......

(5) A translucent body is that through which ......

(6) A shadow cast by heavenly bodies is called......

(7) The part of the shadow called ......is totally dark while the part called ...... is only partially dark.

(8) Magnification in the case of a pin-hole camera is

$$\frac{I}{O}=\frac{\ldots\ldots}{\ldots\ldots}$$

(9) Spot of light on the ground produced by the sun shining through a tiny square hole is ......

(10) The amount of light that falls per second per unit area held perpendicularly to the rays is called ......

(11) The amount of light that falls per second per unit area held at a unit distance perpendiculary to the rays is called ......

(12) Intensity of Illumination$=\dfrac{\text{Illuminating Power}}{\ldots\ldots}$

(13) Lunar eclipse is caused when ...... comes between ...... and ... while solar eclipse is formed when ...... comes between...... and the earth.

(14) A lunar eclipse can never be ......

(15) There are at least ...... solar eclipses every year.

(16) The maximum possible number of solar eclipses is ...... in a year.

(17) The greatest possible time of a total solar eclipse at any one place is......

(18) 1 lux=....../sq. metre.

(19) The quantity of light emitted per second per unit solid angle by a source of one candle power is called ...

(20) A standard candle is made of ...... weighing ...... and...... in diameter and burning at the rate of ......

(21) Light is the ...... cause of vision.

(22) Light-year is a unit of ......

II. Select as directed below and find the completions from the clues provided :

(1) An object that is flooded by light is said to be ...... [incandescent, luminous, illuminated]

(2) To an observer on the moon, the sky would look ...... [the same as on earth ; much brighter, ; rather dull ; absolutely dark]

(3) Bunsen's Photometer uses a/an...... screen for comparing the powers of illumination. [opaque, grease spot, wet]

(4) A sharp and fine image will be produced by a...... hole o the pin-hole camera. [wide, narrow, double]

(5) ......lumens per second is the total quantity of light emitted by a standard candle. [4π, 5π, 6π, 8π]

(6) An object 6 cm. high is placed at a distance of 18 cm. from a pin hole. Its image is formed at 12 cm. from the pin-hole. Therefore the size of the image is ......cm. [18, 12, 6, 4, 2]

(7) An instrument used for measuring the illuminating power of a source is called a ...... [galvanometer, photometer, voltmeter]

(8) A pin-hole camera produces an inverted ...... [picture, image]

(9) The fine hole of a pin-hole camera should be ...... [circular, triangular, rectangular, of any shape]

(10) A pin-hole camera needs ...... [focussing, no focussing]

(11) The shadow cone becomes...as the earth moves away from the sun. [larger, shorter]

(12) An eclipse of the sun can...at full moon. [occur, never occur]

(13) A total eclipse of the moon lasts...at any given place than a total eclipse of the sun. [longer, shorter]

(14) Light rays...under the gravitational fields of stars. [bend, do not bend]

(15) Light ..the property of inertia and therefore of [illegible] [possesses, [illegible] sess]

(16) Light rays and a shower of rain drops differ from each other in having the property of......

[rest mass, inertia, momentum, gravitational pull]

CHAPTER XXIII

REFLECTION OF LIGHT

I. Complete the following sentences with suitable words or phrases :

(1) A rough plane surface reflects the incident light in...directions but a polished plane surface reflects the same in......direction......

(2) For a plane mirror :

(*a*) Size of the...is the same as that of the...

(*b*) Distance of the...is equal to the distance of the...from the mirror.

(*c*) The image is...and...

(3) Reflection means sending back in the...medium by a...... surface.

(4) The focal length of a plane mirror is...

(5) The reflected ray turns through ..the angle through which ...is rotated. This forms the principle of (*a*)...(*b*) ..

(6) ......no. of images are formed when an object is placed between two parallel plane mirrors.

(7) In .., multiple images are formed by inclined mirrors.

(8) In..., successive reflection of light takes place from two plane mirrors.

(9) When two plane mirrors are inclined at an angle θ, the no. of images formed are...

$$n=\frac{\cdots\cdots}{\cdots\cdots}-1, \qquad \text{when}\ldots$$

$$n=\frac{\cdots\cdots}{\cdots\cdots}, \qquad \text{when}\ldots$$

(10) The separation between two objects or between the object and its image, when the eye is moved sideways, is called...

(11) The Rule of Parallax is that the...object moves in the same direction as the eye of the observer.

(12) For seeing the complete image of a man, a plane mirror not smaller than...the size of the man is required.

(13) .. and...image is formed by...and is so used in vehicles near the driver.

(14) The angle subtended at the centre of curvature by two extreme radii on the principal section of a spherical mirror is called its...

(15) The ratio of the diameter of a spherical mirror to its focal length is known as its...

(16) The rays of light are...by a concave mirror and are...by a convex mirror.

(17) Focal length of a spherical mirror is......of its radius of curvature.

(18) ......and......image is produced by a concave mirror, if the object it placed between its......and .....and is so used in the search-light.

(19) Reversed writing appears correct when viewed through a plane mirror because of ..due to reflection.

(20) As the object moves from infinity to the centre of curvature of a concave mirror, the image moves from...to...

(21) After reflection from a spherical mirror, a ray parallel to the principal axis passes through or appears to diverge from its ..

(22) A spherical mirror produces an image 3 times the size of the object. It is a ..mirror.

(23) A spherical mirror produces a virtual image of half the size of the object. It is a...mirror.

(24) A ray of light passing through......of a concave mirror is reflected back along the same path.

(25) For any spherical surface, its

(curvature) × (radius of curvature) = ...

II. Select the correct answers from the clues provided against each statement :

(1) The focal length of a concave mirror is...

[+ve, −ve, zero]

(2) .... mirror is used as a shaving glass.

[Plane, Concave, Convex]

(3) ......images are formed when the two plane mirrors are inclined at an angle of 72°.

[4, 5, 6]

(4) The radius of curvature of a plane mirror is...

[infinite, zero]

(5) Amount of light reflected by water......as the angle of incidence is increased.

[increases, decreases]

(6) Distances are taken as...for real images and objects while those for virtual images and objects are taken as... [+ve, −ve]

(7) The centre of a curved mirror is called its... [pole, focus]

(8) AB is a ray of light incident on a plane mirror PQ at B while the angle of incidence is 30°. BC is the reflected ray and will be back retracing the same path, if another mirror is placed at C, making with PQ an angle equal to... [30°, 60°, 90°, 120°]

(9) Mr. Parvez stands at a distance of 8 metres from a concave mirror of focal length 4 metres ; his image will be...
[magnified, of his own size, diminished]

(10) Maximum candle power of a tungsten lamp is horizontal. This can be remedied by using a...reflector.
[plane, concave, convex]

(11) The image formed by a mirror is virtual and diminished ; therefore...

(*a*) the mirror must be concave and the object is beyond its C.

(*b*) the mirror must be convex.

(*c*) the mirror must be concave and the object is between F and the mirror.

(*d*) the mirror must be plane and the object must be far away from it.

(12) An object is placed at 30 cm. from a concave mirror and its real image is formed at 30 cm. ; the focal length of the concave mirror is...cm. [60, 30, 15]

(13) Writing which has been blotted by a blotting paper can be read with the help of a...mirror. [plane, concave, convex]

(14) Your image appears...on one side of a smooth silver spoon than it does on the other side. [same, different]

(15) It is...to promote the diffusion of light by reflection from a slightly roughened surface. [not possible, possible]

III. Find out which statements out of the following are correct :

(1) $\angle D = (180° - 2\angle i)$ where D is the deviation suffered by a ray incident at an angle i on a plane mirror.

(2) Focal length is the distance between the focus and the pole of the mirror.

(3) For a diffused reflection, the laws of reflection are obeyed for each individual ray.

(4) Frosted glass is used to promote diffusion.

(5) The distance between the centre of curvature and the pole of the mirror is called the radius of curvature.

(6) In the case of a convex mirror of 10 cm. focal length, the image is still within the focus when the object is kept at a distance of 10 cm. from its pole.

(7) Image of an object formed by a concave mirror is brighter than that formed by a plane mirror.

CHAPTER XXIV

REFRACTION OF LIGHT THROUGH PLANE SURFACES AND PRISMS

I. Complete the following sentences with suitable words or phrases :

(1) When a ray of light enters a denser medium from a rarer medium, it bends...the normal.

(2) When a ray of light enters a rarer medium from a denser medium, it bends...the normal.

(3) Refractive index (μ) is given by :

$$\mu = \frac{\sin\ldots}{\sin\ldots} = \frac{\text{velocity of light in}\ldots}{\text{velocity of light in}\ldots} = \frac{\sin\ldots}{\sin\ldots} = \frac{\text{depth}}{\ldots\text{depth}}$$

(4) The critical angle is the angle of...for which the corresponding angle of...is equal to 90°. It is only possible when a ray of light is passing from...to...medium.

(5) A flying aeroplane seems to be...than its actual position.

(6) For refraction through a prism, the ray of light emerges at...the base and $i+e=\ldots+\ldots$

(7) When a ray of light is symmetrically passing through a prism, the prism is said to be in...

(8) Snell's Law is the name given to...

(9) No deviation is suffered by a ray while passing through a glass slab but only a ..

(10) Twinkling of stars results from .. in earth's atmosphere.

(11) The emergent ray in a prism is absent when its angle is greater than...

(12) If the light from an electric filament be reflected from a slab of red glass, two images are seen, one. and other of....colour.

II. Select suitable word or words to complete the following sentences from the clues provided against each :

(1) A monochromatic light wave is entering from one medium into another. Of the following properties of it, the one that remains unchanged is

(*a*) wavelength ; (*b*) amplitude ; (*c*) velocity ; (*d*) frequency.

(2) Transparency of a medium depends upon its...
[nature, thickness, mol. structure]

(3) ...is a constant of refraction between any two media.
[Optical centre, Ref. index, Critical angle]

(4) ${}_a\mu_b \times \ldots \times {}_c\mu_a = 1$.
[${}_c\mu_b$,. ${}_b\mu_c$ ${}_a\mu_c$]

(5) We have $\sin i = \frac{1}{\mu}$; then $\angle i$ is called...

[angle of emergence, critical angle, angle of deviation]

(6) Critical angle for total internal reflection will be smallest for light travelling from...
[water to air ; water to glass ; glass to water ; glass to air]

(7) Critical angle of light passing from glass to air is minimum for

(*a*) red (*b*) green (*c*) yellow (*d*) violet

(8) A swimmer is swimming inside a tank of water. He looks up at the sky in broad-day light through the calm surface of water. He can see

(*a*) nothing but darkness outside the tank.
(*b*) the entire top surface of the water illuminated.
(*c*) a small illuminated patch directly above his head whose angular size is independent of the depth of the swimmer.
(*d*) a small illuminated patch directly above his hand whose angular size depends upon the depth of the swimmer.

(9) Deviation produced by a thin prism is given by $D = (\mu - 1) \times \ldots\ldots$
[i, r, A, e]

(10) The angle of minimum deviation of a prism...upon the colour of the light used. [depends, does not depend]

(11) A ray of light passing obliquely into a medium in which its speed is reduced is bent...the normal. [towards, away from]

(12) Increasing the angle of incidence...the index of refraction.
[increases, decreases, does not affect]

(13) In the minimum deviation position of a prism, the angle of incidence is...to the angle of emergence. [equal, not equal]

(14) In the minimum deviation position of a prism, the angle of refraction at one surface is...to the angle of refraction at the other surface.
[equal, not equal]

(15) The angle of minimum deviation of a ray for a glass prism is least for the light of...colour.

(*a*) red (*b*) green (*c*) blue (*d*) violet

(6) In the case of a convex mirror of 10 cm. focal length, the image is still within the focus when the object is kept at a distance of 10 cm. from its pole.

(7) Image of an object formed by a concave mirror is brighter than that formed by a plane mirror.

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(2) When a ray of light enters a rarer medium from a denser medium, it bends...the normal.

(3) Refractive index (μ) is given by :

$$\mu=\frac{\sin\ldots}{\sin\ldots}=\frac{\text{velocity of light in}\ldots}{\text{velocity of light in}\ldots}=\frac{\sin\ldots}{\sin\ldots}=\frac{\text{depth}}{\ldots\text{depth}}$$

(4) The critical angle is the angle of...for which the corresponding angle of...is equal to 90°. It is only possible when a ray of light is passing from...to...medium.

(5) A flying aeroplane seems to be...than its actual position.

(6) For refraction through a prism, the ray of light emerges out...the base and $i+e=\ldots+\ldots$

(7) When a ray of light is symmetrically passing through a prism, the prism is said to be in...

(8) Snell's Law is the name given to...

(9) No deviation is suffered by a ray while passing through a glass slab but only a ..

(10) Twinkling of stars results from .. in earth's atmosphere.

(11) The emergent ray in a prism is absent when its angle is greater than...

(12) If the light from an electric filament be reflected from a slab of red glass, two images are seen, one. and other of....colour.

II. Select suitable word or words to complete the following sentences from the clues provided against each :

(1) A monochromatic light wave is entering from one medium into another. Of the following properties of it, the one that remains unchanged is

(*a*) wavelength ; (*b*) amplitude ; (*c*) velocity ; (*d*) frequency.

(2) Transparency of a medium depends upon its...
[nature, thickness, mol. structure]

(3) ...is a constant of refraction between any two media.
[Optical centre, Ref. index, Critical angle]

(4) ${}_a\mu_b \times \ldots \times {}_c\mu_a = 1$.
[${}_c\mu_b$,. ${}_b\mu_c$ ${}_a\mu_c$]

(5) We have $\sin i = \frac{1}{\mu}$; then $\angle i$ is called...

[angle of emergence, critical angle, angle of deviation]

(6) Critical angle for total internal reflection will be smallest for light travelling from...
[water to air ; water to glass ; glass to water ; glass to air]

(7) Critical angle of light passing from glass to air is minimum for

(*a*) red (*b*) green (*c*) yellow (*d*) violet

(8) A swimmer is swimming inside a tank of water. He looks up at the sky in broad-day light through the calm surface of water. He can see

(*a*) nothing but darkness outside the tank.

(*b*) the entire top surface of the water illuminated.

(*c*) a small illuminated patch directly above his head whose angular size is independent of the depth of the swimmer.

(*d*) a small illuminated patch directly above his hand whose angular size depends upon the depth of the swimmer.

(9) Deviation produced by a thin prism is given by $D = (\mu - 1) \times \ldots\ldots$
[i, r, A, e]

(10) The angle of minimum deviation of a prism...upon the colour of the light used. [depends, does not depend]

(11) A ray of light passing obliquely into a medium in which its speed is reduced is bent...the normal. [towards, away from]

(12) Increasing the angle of incidence...the index of refraction.
[increases, decreases, does not affect]

(13) In the minimum deviation position of a prism, the angle of incidence is...to the angle of emergence. [equal, not equal]

(14) In the minimum deviation position of a prism, the angle of refraction at one surface is...to the angle of refraction at the other surface.
[equal, not equal]

(15) The angle of minimum deviation of a ray for a glass prism is least for the light of...colour.

(*a*) red (*b*) green (*c*) blue (*d*) violet

(16) In the absence of the atmosphere, the duration of the day will... [increase, decrease]

(17) Looming occurs in... [polar regions, deserts]

(18) A mirage is observed because

(*a*) of reflection of light from hot sand.

(*b*) the refractive index of the atmosphere decreases with height.

(*c*) the refractive index of the atmosphere increases with height.

(19) A fish...see the sun rising or setting. [can, cannot]

(20) We see heavenly bodies in their true position when they are...the horizon. [away from, near]

(21) Comparing the rays of sun falling on the earth at noon, in the morning and in the evening, we can say that

(*a*) the evening rays will bend more away for earth than the noon rays.

(*b*) the evening rays bend more towards the earth than the noon rays.

(*c*) the morning rays will bend more towards the earth than the evening rays.

(*d*) the morning and evening rays bend away from the earth equally.

(22) Water is transparent to visible light. Still it is not possible to see objects at a distance in fog which consists of fine drops of water suspended in air because

(*a*) fine drops of water are opaque to visible light.

(*b*) most of the light is scattered and hence this apparent opacity.

(*c*) fog affects our vision.

(*d*) the light rays suffer total internal reflection and hence can not reach the eye.

III. Suggest suitable scientific terms for the following :

(1) In a homogeneous medium, light travels in st. lines.

(2) When a ray of light passes from one homogeneous medium into another, it is generally propagated in a direction which is not the same as that in which it originally travelled.

(3) Newton regarded a beam of light as a train or swarm of tiny particles or corpuscles (named photons) that are emitted from light-sources and fly at a very high speed through space.

(4) According to Newton, some of the emitted photons are repelled (to account for reflection) by the medium and some attracted (ot account for refraction) by the transparent medium.

(5) A phenomenon in which no refraction takes place and full light is restricted to one medium only.

(6) A prism which can make a ray of light suffer a deviation of 180° so that the inverted object appears erect.

(7) An optical illusion which causes a tarred road in summer to appear like a pool of water.

(8) An optical illusion in which the inverted images are seen hanging up in the air in the polar regions.

(9) A portion of a transparent medium bounded by two plane refracting surfaces meeting at an angle.

(10) A section cut out by a plane at right angles to the edge of a prism.

CHAPTER XXV

REFRACTION OF LIGHT THROUGH LENSES

I. Complete the following sentences with suitable words or phrases :

(1) A lens is so called because of its similarity in shape to...

(2) ......is a point on the principal axis of a lens, on passing through which a ray of light suffers no deviation.

(3) ...is a point where a parallel beam of light, after refraction through a lens, converges to or appears to diverge from.

(4) The focal point for a combination of a concave lens and a a convex lens when placed in contact is ..

(5) ...are two conjugate points on the principal axis of a lens for which magnification is +1.

(6) If x_1, x_2 be the distances of the conjugate points measured from the principal focus of a lens, then its focal length is given by the formula (known as Newton's formula)......

(7) Magnification produced by lenses is given by :

$$m=\frac{I}{O}=\frac{\dots}{\dots}=\frac{f}{\dots}=\frac{\dots}{f}$$

(8) Focal length F and the power P of the combination of several thin lenses in contact are given by the relations :

$$\frac{1}{F}=\dots\dots : \qquad P=\dots\dots$$

(9) The power P of a lens is expressed in... and $P=\frac{1}{\dots}$ when .. is expressed in metres.

(10) A lens is concave when its focal length is...and is convex when it is...

(11) A convex lens generally forms...images while a concave lens always forms...images.

(12) A...lens magnifies the printed words-

(13) The diminished image formed by a convex lens cannot be......

II. Select suitable word or words to complete the following sentences from the clues provided against each :

(1) An object is placed between F and $2F$ in front of a concave lens, the image is formed between......
[F and the lens, F and $2F$, $2F$ and infinity]

(2) An object is placed at $2F$ of a convex lens ;......image is formed. [equal, diminished, magnified]

(3) A......image is formed when an object is placed between F and the optical centre of a convex lens. [virtual, real, double]

(4) An object is placed between F and $2F$ in front of a convex lens ;......image is formed.
[real, virtual, magnified, same size, diminished]

(5) Formula $f=\frac{l^2-d^2}{4l}$ is used in......method for finding the focal length of a convex lens.
[displacement, combination, plane mirror]

(6) Conjugate foci exist for......
[concave/convex mirror, concave/convex lens]

(7) Given a point source of light,......can produce a parallel beam of light.

(*a*) concave/convex mirror, (*b*) concave/convex lens
(*c*) two plane mirrors at 90° to each other

(8) In the......aberration of lenses, blurred and less sharply defined images are formed. [spherical, chromatic]

(9) The formation of coloured images by a lens is due to...... aberration. [spherical, chromatic]

(10) Spherical aberration can be removed by using...
[central spot of the lens, cylindrical lens, plano-convex lens, combination of concave and convex lenses]

(11) An object is taken near a lens and is viewed from the other side. If the image is found to be magnified, the lens is......If the image is found to be diminished, the lens is......If the image is of the same size as is the object, it is......
[concave, convex, plane glass]

(12) If the focal length of a concave lens is 50 cm., its power is...dioptres. [+5, +2, −2]

(13) Two thin lenses of focal lengths +20 cm. and −40 cm. are in contact. The focal length of the combination is...cm. [0, −20, +20, +40]

(14) A double convex air bubble in water will behave as a...

(*a*) convergent lens. (*b*) divergent lens.

(*c*) plane slab. (*d*) concave mirror.

III. Suggest suitable scientific terms for the following statements :

(1) Phenomenon in which the left hand side of the object appears as the right hand side of the image.

(2) The ratio of the size of a given spherical mirror to the diameter of the sphere whose portion is this mirror.

(3) Portion of a transparrent medium bounded by two surfaces, out of which at least one is a curved surface.

(4) St. line passing through the centres of curvature of the two spherical faces of a lens.

(5) A pair of points such that when the object is placed at one point, its image is formed on the other point.

(6) Apparent shift between two objects when eye is moved to left or right.

(7) Property of a lens which determines the magnitude of its ability to deviate a ray from its original path after refraction.

CHAPTER XXVI

OPTICAL INSTRUMENTS

I. Complete the following statements with suitable words or phrases :

(1) A telescope is used to see......objects while a microscope is used to see...objects.

(2) The focal length of the objective lens of a compound microscope is...and that of its eye-piece is...

(3) The focal length of the objective lens of a telescope is...... while that of its eye-piece is...

(4) A projection lantern is used for projecting a real magnified image of whereas the episcope does the same for...objects.

(5) A terrestrial telescope forms an .....image while......image is formed by an astronomical telescope.

(6) The...microscope is merely a convex lens.

(7) The magnifying power of a microscope

$$=\frac{\text{angle subtended at the eye by the...}}{\text{angle subtended at the eye by the...}}.$$

(8) The camera lens should be moved...the screen for taking the photograph of a large size object.

(9) Ratio of the diameter of the diaphragm to the focal length of a lens is called its...

(10) ...is used for seeing three-dimensional pictures.

(11) The least distance of the distinct vision for a normal eye is ..

(12) The distance between the eye-piece and the objective lens of an astronomical telescope is equal to the...of their focal lengths.

(13) The distance between the eye-piece and the objective lens of a Galilean telescope is equal to the...of their focal lengths.

(14) In a compound microscope, the distance of the object from the objective lens is......than the focal length of the objective lens.

II. Select for the following statements the completions from the clues provided against each :

(1) Pupil ...when bright light is suddenly shone on the face. [expands, contracts]

(2) Pupil......when we enter a dark room. [expands, contracts]

(3) The power of the eye which enables it to focus objects at varying distances away is called... [myopia, retina, accommodation]

(4) Focal length of the eye-lens is controlled by... [ciliary muscles, iris, retina, vitreous humour]

(5) When image falls ahead of retina, a person is said to have ...... [myopia, hypermetropia, presbyopia]

(6) Presbyopia is due to...while astigmatism is due to...

(*a*) loss of accommodating power of the eye.

(*b*) the curvature in the cornea of the eye.

(7) Longsightedness is cured by using......lenses and shortsightedness is cured by using......lenses and astigmatism is cured by using...lenses. [concave, convex, cylindrical]

(8) In shortsightedness, one cannot see clearly at . distances and in longsightedness, one cannot see clearly at . ... distances. [short, long]

(9) The eye differs from a camera, because

(*a*) the focal length of the eye-lens can be changed.

(*b*) anterior and posterior chambers are filled with fluids.

(*c*) the distance between the retina and the eye-lens is fixed.

(*d*) the focal length of the camera lens is fixed.

(10) The eye has the following advantages over the camera :

(*a*) it sees objects in their true colour ;
(*b*) it has binocular vision ;
(*c*) it sees objects in perspective ;
(*d*) it sees all details more clearly ;
(*e*) it is not biased.

(11) The camera has the following advantages over the eye :

(*a*) it has no prejudice ;
(*b*) it shows objects in their true position ;
(*c*) it does not suffer from fatigue ;
(*d*) it is self-focussing ;
(*e*) it gives a composite figure.

(12) Condenser of a magic lantern is used to

(*a*) make the object appear larger ;
(*b*) focus an intense spot of light on the object ;
(*c*) make the light diverge onto the object.

(13) After focussing the image of a projection lantern on the screen, the lantern is moved further away from the screen. To refocus the image, the lens is to be moved towards the .....

[screen, slide]

(14) Depth of focus of a camera can be ...... by reducing the aperture of its lens. [decreased, increased]

(15) While taking photographs with a camera, if one wants that every object beyond one metre should be in focus, one should

(*a*) give short exposure without changing aperture.
(*b*) reduce the aperture and increase the time of exposure.
(*c*) increase the aperture and decrease the time of exposure.
(*d*) give long exposure without changing the aperture.

(16) The eye is a very ...... colour receiver.

[selective, non-selective]

(17) A fly is sitting on the objective of a telescope pointed towards the moon. What effect is expected in a photograph of the moon taken through the telescope ?

(*a*) The entire field of vision is blocked.
(*b*) There is an image of the fly on the photograph.
(*c*) There is a reduction in the intensity of the image.

III. Suggest suitable scientific terms for the following :

(1) Instruments utilising the combination of mirrors, prisms and/or lenses.

(2) Instruments used for seeing very very small objects.

(3) Instruments for seeing distant or far off objects.

(4) Instrument which combines in itself the working of a magic lantern and that of an episcope.

(5) Most sensitive part of the retina of an eye.

(6) Most insensitive part of the retina of an eye.

(7) Liquid in the eye responsible for tears.

(8) Property of an eye due to which the fast revolving blades of a table fan give the appearance of a moving disc.

(9) Defect of eye on account of which the eye cannot form a point image.

(10) A term connected to an optical instrument giving the ratio of the angle subtended by the image on the eye to the angle subtended by the object on the eye.

(11) An eye capable of seeing any object placed anywhere between 25 cm. and infinity.

(12) The distance between the nearest and farthest objects which are just sufficiently in focus to look reasonably clear in a photographic print.

(13) Instrument comprising of two Galilean telescopes.

(14) An instrument with the help of which a person sitting under the surface of water can see things happening on the surface of the sea.

(15) An instrument whose size is invariably equal to one-sixth of a circle.

IV. Which of the following statements are correct and which are wrong ?

(1) Both the lenses are convex in a Galilean telescope.

(2) Circular aperture of the eye is called pupil.

(3) The power of a telescope by which the details of the image can be observed is called its resolving power.

(4) A blind spot and a yellow spot in the eye are one and the same.

(5) When the cornea is irregular, lines in some directions are not focussed so sharply as others.

(6) In dim light, the eye is most sensitive to the central part of the visible spectrum.

(7) Telescope acts as a microscope in its reversed position.

(8) A magnifying glass consists of a single convex lens.

(9) A photographic camera produces a real image.

(10) When a photograph is taken of a person sitting on the ground with his feet towards the camera, the photograph shows the feet to be abnormally large.

(11) An astronomical telescope is greater in length than the Galilean telescope of the same magnifying power.

(12) By the use of binocular vision, we gain depth of vision.

(13) The third lens near the middle of the tube of a terrestrial telescope is used to enlarge the image.

CHAPTER XXVII

DISPERSION AND VELOCITY OF LIGHT

I. Complete the following statements with suitable words or phrases :

(1) White light on passing through a prism splits up into...... colours called......

(2) A...... spectrum can be obtained on the screen while a...... spectrum can only be seen.

(3) In a......spectrum, there is no overlapping of colours.

(4) The prism must be placed......for getting a pure spectrum.

(5) ......has the longest wavelength while......has the shortest wavelength in a visible spectrum.

(6) When a glass slab is viewed in red light instead of blue light, its apparent thickness will......

(7) ......is used for the study of spectra and their measurement with different lights.

(8) "Dispersion without deviation" is studied by a......

(9) ......or......spectra are observed when the substance is in the form of atoms while......or..... spectra are observed when the substance is in the form of molecules

(10) Solar spectrum indicates the presence of......in the sun's atmospehere and its hot and cold regions are demarcated by .....lines which are called ...lines after the name of its discoverer......and these are ...in number.

(11) Light and radiant heat travel with......velocities.

(12) The velocity of light is ..... in air than in glass or water.

(13) The velocity of light was accurately determined by......by his famous ...method in which the distance between the two stations was......

(14) Time taken by the light to go and return is the same as the time taken by one......to take the place of the next...... in Michelson's Octagonal Mirror Method. Then the velocity of light is given by the formula

$$V = \ldots\ldots(8n.d)$$

(15) A green glass appears green because it......the green colour and absorbs the rest.

(16) The part of the spectrum beyond the violet which is not visible to the eye, is called......

(17) An infra-red photograph of a seascape shows the sea as...... and the foliage of the tree as......

(18) Sunburn is caused by......in the radiant energy spectrum.

(19) Any two colours which on mixing together produce white colour, are called......colours.

(20) A person who is colour blind has difficulty in distinguishing between......and......colours.

(21) The......light indicates the colour of an opaque body.

(22) A thin gold foil appears......by reflected light.

(23) A thin gold foil appears......by refracted light.

II. Select suitable completions for the following statements from the clues provided against each :

(1) The definite proof of the velocity of light was given by ......first of all. [Roamer, Fizeau, Michelson]

(2) In a spectrometer, a prism is used to......the light. [reflect, transmit, disperse]

(3) Parallel beam of light is produced by a......in the spectrometer. [collimator, turn table, telescope]

(4) A......spectrum depicts all the colours. [line, continuous, band]

(5) A......spectrum shows all the colours with discrete linings. [line, band, emission]

(6) Discontinuous spectra are called......line spectra. [bright, dark]

(7) Sodium light produces a......spectrum. [continuous, line, band]

(8) ......spectra are formed by white-hot solids. [Continuous, Line, Band]

(9) The sun and the stars produce......spectra. [absorptive, discontinuous]

(10) Burning sodium vapour yields......spectrum. [absorptive, discontinuous]

(11) ......is said when different angles of deviation of different colours exist on passing through a prism. [Spectrum, Refrangibility]

(12) ......is the part of the spectrum beyond the red which is not visible to the eye and has longer wavelength. [Infra-red, Vibgyor, Colourless]

(13) ... is the most deviated while .....is the least deviated colour in the solar spectrum. [red, violet, green]

(14) White light is... ..when passing through the prisms of binoculars. [dispersed, not dispersed]

(15) ......colour is produced when the spectral blue and yellow colours are mixed. [Yellow, Green, White]

(16) ......colour is produced when blue and yellow pigments combine. [White, Green, Red]

(17) A blue cross on a white background is illuminated with white light and is observed through a red filter. We see......

- (*a*) a red cross on a black background.
- (*b*) a blue cross on a red background.
- (*c*) a red cross on a blue background.
- (*d*) a black cross on a red background.
- (*e*) a black cross on a black background, *i.e.* nothing.

(18) Which of the following objects will appear invisible ?

- (*a*) A blue object on a white background seen through a blue filter.
- (*b*) As (*a*) but seen through a red filter.
- (*c*) A green object on a red background, illuminated by red light.
- (*d*) A white object on a blue background, seen through a red filter.
- (*e*) As (*d*), but illuminated with only blue light.

(19) All colours ranging from violet to red are found in the light emitted by......

- (*a*) all incandescent objects. (*b*) molten iron.
- (*c*) discharge tube containing argon gas.
- (*d*) barium chloride when introduced in Bunsen flame.

(20) Which of the following statements is false ?

- (*a*) The spectrum of light emitted by a tungsten filament lamp is continuous.
- (*b*) The colours obtained in the light emanating from incandescent objects are all equal in amount.
- (*c*) A gas at low pressure emits spectrum when excited electrically.
- (*d*) The line spectrum differs from element to element.

(21) Which of the following sources gives discrete emission spectrum ?

(*a*) Incandescent electric bulb (*b*) Sun

(*c*) Mercury vapour lamp (*d*) Candle

(22) Which of the following types of electromagnetic waves has the longest wavelength ?

(*a*) X-rays (*b*) Infra-red

(*c*) Visible light (*d*) Radio waves

(23) Of the following, moving with the same velocity, which has the largest wave-length ?

(*a*) Electron (*b*) Proton

(*c*) Helium nucleus (*d*) Cricket ball

(24) In Q. 23 above, which one having the same kinetic energy will have the largest wave-length ?

(25) Which of the following statements concerning photoelectric effect is false ?

(*a*) It displays the particle nature of light.

(*b*) Electrons are emitted only if light has a frequency above that of a critical frequency.

(*c*) All electrons emitted at a particular frequency have the same energy.

(*d*) Changing the intensity of the light changes the energies of the electrons.

(26) Which of the following statements concerning light is incorrect ?

(*a*) Light is a form of energy.

(*b*) All photons possess the same amount of energy.

(*c*) Light radiation belongs to the electromagnetic spectrum.

(*d*) A beam of light can not be a magnet.

III. Pick out the correct and the wrong statements separately from the following. Also correct the wrong statements.

(1) A white body reflects all the colours while a black body absorbs all the colours incident on it.

(2) Red, green and blue are known as primary colours.

(3) Green colour is produced when pigment blue colour is mixed with yellow colour.

(4) Line spectra are emitted by sodium light while continuous spectra are emitted by white light.

(5) Band spectra are emitted by a discharge tube filled with nitrogen gas at low pressure.

(6) Emission spectrum is obtained when a substance is heated to incandescence.

(7) Absorption spectrum is obtained when "some thing" is placed in the path of light giving a continuous spectrum which absorbs some colours.

(8) Rainbow is seen with our back towards the sun.

(9) Rainbows are formed by the reflection and refraction from the water particles suspended in the atmosphere.

(10) Yellow and blue are complementary colours.

(11) A red rose appears black when blue light falls on it.

(12) Red flowers look white against a green background because the two colours are complementary.

(13) If a red book is observed in red light, the book will appear black.

(14) Red+Blue=Magneta.

(15) Blue+Green=Peacock-blue.

(16) Green+Magneta=White.

(17) Green+Peacock-blue=White.

(18) Magneta+Yellow+Peacock-blue=White.

(19) Lights of different colours travel with different velocities through vacuum.

(20) Light and radiant heat travel with the same velocity.

(21) A surface apoears gray when the amounts of light absorbed and reflected are about equal.

(22) Flourescence is the process or phenomenon in which substances give off light upon absorbing radiant energy.

(23) Anything illuminated in green light looks black through a red filter.

(24) A rainbow is never seen at midday except in winter.

(25) Red ink which has dried on a pen-nib appears green.

(26) The frequency of light having a wave length 3000A° is 10^{15} cycles/sec.

Short-Answer Questions

1. *What is light ?*

Ans. Light is defined as energy radiated from a body which produces the sensation of sight upon the eye. It is a form of energy as it does not occupy space or has no weight.

2. *Is light homogeneous ?*

Ans. Light radiations are not regarded as homogenous. It is composed of various colours, each colour corresponding to different wavelengths. The eye is not equally sensitive to all colours (or wavelengths) ; it has maximum sensitivity at wavelength 5500 *A.U.* and minimum at below 4000 *A.U.* and above 6500 *A.U.*

3. *Why can we see the shadow of a flying bird when it is near the ground but not when it is higher up in the sky ?*

Ans. A shadow (umbra) is formed on the ground when the bird is near to it because *the bird is very small as compared to the source of light, i.e.* sun. When the bird is higher up in the air, umbra is formed in the air and does not reach the ground. Only the faint penumbra reaches the ground but that is not visible.

4. *Sunlight enters a dark room through a hole in a shutter. Are we really seeing light ?*

Ans. Light stimulates the sense of sight. Light itself is not visible but it makes other things visible. It is thus the physical cause of vision. Above the earth's atmosphere it is pitch dark—only here and there are some white specks visible which are in reality some objects (in space) on which light is falling. Similarly a beam of sunlight entering a dark room through a hole is *not visible* except for the small motes or dust particles present in its path. Thus we are not really seeing the rays of light.

5. *Why cannot a searchlight beam be seen after a shower of rain ?*

Ans. Light is scattered by the dust particles and these are the illuminated dust particles in the path of the light and not the light itself which are seen. After a shower of rain has washed most of the dust particles out of the air, a searchlight beam cannot be seen (except where the light illuminates the clouds).

6. *Why are stars visible at mid-day from the bottom of the well or a tall chimney ?*

Ans. Because their light is not overpowered by the sun, and the rays of the sun shine obliquely across the end of the well or chimney whereas the light from some stars will shine directly down the well.

7. *An eclipse of the sun is being observed. At one moment when the eclipse is decreasing, the edge of the sun, the edge of the moon and the observer's eye are in the same straight line. How soon after this will the observer first see the sunlight ?*

Ans. The observer will first see the sunlight after that period of time has elapsed which is necessary for light to travel the distance from the moon to the observer's eye, *i.e.* about $\frac{1}{3}$ second.

[**Note** : At the time of total solar eclipse, a beautiful pearly glow, termed as **corona**, surrounds the sun. It is probably due to the lighting up of fine dust forced out upto millions of miles from the sun's surface by the pressure of light.]

8. *A lunar eclipse is a little disappointing when seen for the first time because the moon does not vanish completely. Why is it so ?*

Ans. This is because the earth's atmosphere bends (refracts) the sunlight, so the umbra is not perfectly dark ; some light reaches the moon. This light is predominantly red in colour because red is least scattered by the atmosphere ; most of the blue light is scattered and does not reach the moon. So the moon assumes a dull coppery colour.

[**Note** : (*i*) No such atmospheric effect occurs during a solar eclipse because the moon has no atmosphere.

(*ii*) The greatest possible time of a total solar eclipse at any one place is only 7·5 minutes.

(*iii*) There are at least **2** solar eclipses every year, the maximum number possible being **5**.]

9. *A room is lighted by two electric bulbs fixed on opposite walls. How will you tell without using a photometer or reading off from the bulbs or guessing, which of the two bulbs is of higher candle power ?*

Ans. (**i**) : A brighter source of light causes a darker shadow and *vice versa*. Using this fact and the knowledge of Rumfords's shadow photometer, *instal yourself at the* **centre** *of the room* and look at the two shadows of yours cast on the floor. The bulb on the side opposite to that of the darker shadow will be of higher candle power.

[**Note** : Here the effect of distance (*i.e.* inverse square law) will be same for both. The darkness of the two shadows is decreased by the intensity of illumination of the bulb on the side of the shadow under consideration.]

Ans. (**ii**) : In-between the two bulbs, adjust your position such that the two shadows of yours are equally dark. Then the bulb which is at a greater distance from you will be of higher candle power.

[**Note** : Here, the darkness of a shadow has been decreased by the intensity of illumination of the bulb on the side of the shadow.

Because it is only when equals are subtracted from equals, that the remainders are equal, therefore, the intensities of illumination of the two bulbs on your feet will be equal. Since the intensity at a point is directly proportional to the power of the bulb and inversely proportional to the square of the distance apart, therefore, the bulb situated at a greater distance from you will be of higher power.]

10. *In the use of radar, a beam of radiation is sent out from a source. Some of this radiation falls on a distant object, is reflected by the object and is detected when it returns to its starting point. The radiation used behaves like light. How will you justify that the intensity of the returning radiation varies inversely with the fourth power of the distance from the source to the reflecting object ?*

Ans. Let L be the power of radiation source and r its distance from the distant object. Then the intensity of radiation or light at the distant object is :

$$I = L/r^2$$

The amount of light or radiation which this object reflects is proportional to the incident intensity. If C be the coefficient of reflection of this object, then it becomes a source of power CL/r^2. Therefore, the intensity of the returning light or radiation at the radar station is :

$$I' = \frac{CL/r^2}{r^2} = \frac{CL}{r^4}; \quad \text{or} \quad I' \propto \frac{1}{r^4}$$

11. *In the shade of a tree on a sunny day at noon, numerous circular patches of light are noticed. How do you explain their presence ?*

Ans. Round patches of light are the inverted images (in reality picture, and not image) of sun which is itself round. These patches are formed by the small gaps or openings between the leaves of the tree, acting as several pin-holes while the ground serves the purpose of a screen.

12. *What should be the shape of the hole in a pin-hole camera ?*

Ans. *Shape of the hole can be any* as long as it is neither too small nor too large. This is justified by noticing round patches of light under a tree on a sunny day where sun is the object, ground is the screen and small gaps between the leaves of the tree serve the purpose of holes which are definitely not of one particular shape.

13. *What should be the size of the hole in a pin-hole camera ?*

Ans. The *hole should neither be too small nor too large.* When the hole is very small, no faithful image will be formed but only *coloured rings* will appear on the screen. On the other hand, when the hole is very large, it can be supposed to consist of many small holes—each producing the image of the given object at slightly different places. This will result in considerable overlapping of various images, producing a final *blurred image.*

14. *State the advantages of a pin-hole camera over a photographic camera.*

Ans. (*i*) In the absence of a lens, a pin-hole camera requires a long exposure of about 2 minutes. The long exposure would have the advantage that people walking about in front of the object to be photographed would not appear in the photo.

(*ii*) In the absence of a lens, it forms a picture which is a true copy of the object *i.e.* defects of curvature and distortion, chromatic aberration, etc. are absent.

(*iii*) Its field of view is wide.

(*iv*) No focussing is required.

[**Note** : Use a "**Slit-camera**" in which two narrow slits perpendicular to each other are placed at a distance between the object and the screen. If you draw rays passing straight through these slits, you will notice that the length of the object has increased and breadth diminished or *vice versa* as it appears on the screen. This is used for (*i*) getting caricatures, (*ii*) varying architectural designs and carpet and wall-paper patterns and (*iii*) distending or condensing any ornamental motif.]

15 *If you can see the eyes of someone in a complicated system of mirrors, is it possible for him to see your eyes* ?

Ans. Light travelling from the eyes of the other person towards your eyes must follow the same path as light travelling from your eyes to his eyes. This is true because the angle of incidence equals the angle of reflection. Hence the other person *can see your eyes* (due to reversibility of the path of light).

16. *A plane mirror kept outside in the sunlight is visible only from one particular direction while a wooden plank can be seen from every direction. Why is it so* ?

Ans. An opaque body is visible with the help of the light reflected by it. From the polished and smooth surface of a plane mirror, the incident parallel beam of sunlight is reflected as a parallel beam in a particular direction (obeying the laws of reflection). Evidently, the mirror will be visible only when your eyes lie in the path of the reflected beam.

But the surface of a wooden plank is rough. Therefore, the incident parallel beam of sunlight is reflected in all directions due to irregular reflection (yet in accordance with the laws of reflection.) for each ray). On account of this diffused or scattered light, the wooden plank is visible from every direction.

17. *What do you mean by twilight* ? *What is it due to* ?

Ans. The faint light before sunrise and after sunset is called twilight. It is due to the irregular* reflection of *just sunrise or sunset rays* occuring at the dust particles, clouds, etc. floating in the air.

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*White appearance, whether of foam, paper, ground glass, white-wash or anything else that looks white, is due to the reflection of light from an irregular surface.

Thus the earth continues to get for some time the diffused or scattered light.

[**Note** : *Similarly explain* why every part of a room having only north windows is illuminated at noonday.]

18. *Some of the moon's surface is rough and other parts are smooth. Are the bright areas of the moon rough or smooth ?*

Ans. The bright spots of the moon are rough. A rough surface would scatter light, making it possible to see the reflected light from any angle. Unless you are at one certain place, a smooth surface appears dark when held in a light.

19. *What is an image ? Distinguish between real and virtual images.*

Ans. Rays starting from a point after reflection or refraction from a reflecting or refracting surface, either converge to or appear to diverge from a second point called the **image** of the first point. As long as the object does not change its position, its image will also lie at a fixed place.

(*i*) When the reflected or refracted rays converge, the image is *real* and it can be received on the screen. It is always inverted w.r.t. the object.

(*ii*) When the reflected or refracted rays appear to diverge, the image is *virtual* and it can not be received on the screen. It is always erect w.r.t. the object.

[**Note** : A plane mirror produces a virtual image except when it has a converging incident beam.]

20. *Distinguish between a shadow and an image.*

Ans. *Image* : It is a point to which the reflected or refracted pencil of rays converges or from which it appears to diverge. It is also a source of light and is the lighted object. It is always formed at a fixed place as long as the position of the mirror or the lens remains fixed w.r.t. the object.

Shadow : It is the region not receiving light (fully or partly) due to an obstacle in the path of light.

21. *"A pin-hole camera does not produce an optical image"— justify.*

Ans. The inverted picture obtained on the screen of a pin-hole camera does not satisfy the conditions of an optical image since (*i*) the rays starting from the object are neither reflected nor refracted at the pin-hole, (*ii*) the rays neither converge to nor appear to diverge from the screen, and (*iii*) the screen can be placed anywhere to get inverted picture on it while the image is always formed at a fixed position as long as the object remains at the same place.

22. *How can you know the three kinds of mirrors without touching them ?*

Ans. Bring your face quite close to the mirrors one by one and see the size of the erect and virtual image.

(*i*) It will be a *plane mirror*, if the size of the image appears to be same as original.

(*ii*) It will be a *convex mirror*, if the size of the image is smaller than the real size of the face.

(*iii*) If the size of the image is larger than the face, then it will be a *concave mirror*.

23. *Why do we get a virtual image in a plane mirror ?*

Ans. If we consider a plane mirror to be a spherical mirror of infinite focal length, then using the formula

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \text{ we get } \frac{1}{u}=-\frac{1}{v} \text{ or } u=-v$$

It shows that the image is formed as far behind the mirror as the object is in front of it. The negative sign shows that the image is virtual.

24. *Why does a cheap looking-glass give a distorted and dim image ?*

Ans. A cheap looking-glass is neither plane nor of uniform thickness If it is not plane, it will possess concavity or convexity of different amounts at different parts of the surface. It will produce unequal magnifications at different parts of the image. Hence the image will appear *distorted*.

If the thickness is not uniform, the reflected light (from back polished surface) will spread in a greater area because the angle between any two reflected rays will not be the same as that between the corresponding incident rays. This will result in a *dim* image.

25. *Why do we not see ourselves so well in a piece of plane glass as in a mirror ?*

Ans. It is because when a ray of light enters a transparent medium such as glass, it continues in its original direction until it meets with an opaque substance ; then it is reflected or sent back. When the light meets the surface of the quicksilver at the back of the mirror, it turns back and passes out again at the same surface at which it entered. This turning back or reflection does not occur so perfectly with unsilvered glass, hence the reflected image is dimmer than it is with a mirror.

26. *How do you know that it is not the front surface of a plane mirror which reflects ?*

Ans. (**i**) : Verify the laws of reflection with 4-pin method. It will be found that the incident ray and the reflected ray do not meet at the front surface of the mirror.

Ans. (**ii**) : Place any point of an object against the face of the plane mirror. It will be noticed that the image of this point is not touching this point - the two are some distance apart. This distance equals twice the thickness of the mirror since the image is as far behind the plane mirror as the object is in front of it.

27. *Why are plane mirrors often used at cross roads and in corridors ?*

Ans. Normally we can not see around corners and therefore we cannot observe the approaching traffic round them. But a plane mirror reflects the incident light in a new direction ; this helps in seeing the approaching traffic.

28. *An optician, whose consulting room is not long enough for testing eyes, can double the effective length of his room by means of a plane mirror. How ?*

Ans. Since the image formed by a plane mirror is as far behind the mirror as the object is in front of it, therefore by fixing a plane mirror on the wall facing the eye-testing chart and making the patient sit under the chart, the optician is able to double the effective length of his room. The patient will be asked to read the letters from the image of the chart.

[**Note** : By placing plane mirrors on both the walls facing each other, the length of the room can be expanded to a very great distance since the successive reflections will take place from parallel mirrors.]

29. *Why do the windows of a house seem dark in daylight i.e. darker than the walls of house, even though the walls are painted with some dark colour ?*

Ans. Brightness of an object depends upon the fraction of the incident light reflected by the object. A transparent window allows maximum light to pass through it and only a small portion of the incident light gets reflected from it. On the other hand, the reflection of light is always much greater from opaque walls. Hence the difference in their brightness.

30. *Why do we seem to stand on our head when we see our reflection in water ?*

Ans. The surface of water behaves as a plane reflecting surface. We know that in a plane mirror, image formed is as far behind the mirror as the object is in front of it. Our feet are nearest to the surface of water, they must therefore seem so in the reflection. On the other hand, the head which is more remote must also seem more distant from the surface of water which reflects it.

31. *We can look at the image of the sun in water at noon but not in the afternoon. Why ?*

Ans. The part of light which is reflected from a surface depends upon the angle of incidence—greater the angle of incidence, larger the portion of light reflected.

Near about noon, sunlight falls approximately normally *i.e.* the angle of incidence is very small. Hence most of the incident light passes through water and very little light is reflected which will not be dazzling to the eyes.

But in the afternoon, the angle of incidence increases and therefore a large portion of the light will be reflected which will dazzle our eyes and we will not be able to see the image of the sun.

32. *A large plane mirror stands vertically at a certain distance from a man who sees his image* in it. Find his rate of motion w.r.t. his image when (i) the man moves at the rate of 3 metres/sec. towards the fixed mirror, (ii) the man is stationary and the mirror moves at the rate of 3 m sec. towards the man, (iii) the man and the plane mirror both move towards each other at the rate of 3 m/sec.*

Ans. We know that in a plane mirror, *the image is formed as far behind the mirror as the object is in front of it.*

Case (i) : When the man moves at the rate of 3 metres per second towards the mirror, his image will also move at the same speed towards the mirror. Therefore his relative velocity w.r.t. his image is :

$$v_1 = 3 + 3 = 6 \textit{ metres/sec.}$$

Case (ii) : The mirror moves towards the man by 3 metres in one second and so does his image. Therefore his relative velocity w.r.t. his image is :

$$v_2 = 3 + 3 = 6 \textit{ metres/sec.}$$

Case (iii) : When both move towards each other at the rate of 3 m/sec., that means they approach each other by 3+3=6 metres in one second. Therefore his relative velocity w.r.t. his image is :

$$v_3 = 6 + 6 = 12 \textit{ metres/sec.}$$

33. *How will you locate the position of a Junction (to minimise the cost on the length of rails) on the existing railway line for two new cities coming up in the interior on the same side of the line ?*

Ans. Let us consider the railway line as a plane mirror since the light chooses the shortest† and fastest of all possible routes between its source, the mirror and the eye. Let the source be one city (say A) and the eye another city (say B). To locate the position of junction (say C) so that AC and BC are equally inclined to the plane mirror, locate the image A' of A (the image being as far behind the mirror as the object is in front of it) and join $A'B$ cutting the line at C.

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*Quite often one may put a lamp behind oneself to "light-up" his reflection or image in a mirror instead of throwing the light on his own person from front.

†While reflecting, light follows the shortest route ; while refracting, the light chooses the fastest way.

34. *State the physical principles made use of, in the case of the following :*

(*a*) *Sextant* (*b*) *Kaleidoscope* (*c*) *Periscope.*

(*d*) *Concave mirror used as a shaving glass.*

(*e*) *Convex mirror used in a motor car.*

(*f*) *Mirror galvanometer with lamp and scale arrangement.*

Ans. (**a**) : $\beta=2\theta$, that is when the plane mirror moves through a certain angle (θ), the reflected ray moves through double that angle.

(**b**) : Multiple images are formed by inclined mirrors due to multiple or successive reflections.

(**c**) : Successive reflections of light from two plane mirrors, each kept at 45° to the incident light.

(**d**) A virtual, erect and enlarged image is obtained of an object placed very near the concave mirror *i.e.* between its focus and pole.

(**e**) : A convex mirror gives a wider field of view and it forms a virtual, erect and diminished image.

(**f**) : Same as (**a**).

[**Note** : (*i*) In a *search-light* we should use a concave mirror of large aperture or a parabolic mirror so that light can be concentrated on any distant object.

(*ii*) In street lighting, a convex mirror is preferred as that will diffuse light to a greater region.]

35. *Why is a motor-car rear-view mirror made convex ?*

Ans. It is due to the following reasons :

(1) A covex mirror always forms an *erect image* of the moving objects following or passing your car from behind, irrespective of the distance of the object. Terrestrial objects cannot be recognised in their inverted position.

(2) As the *size of the image* of the approaching object gradually decreases, it helps the driver in judging the *distance** as well as the *speed* of the approaching object.

(3) Since the image is reduced, a small convex mirror gives a picture showing all objects on a considerable length and width of the road. On the other hand, for such satisfactory results, a plane mirror or a concave mirror would have to be too large to be convenient. In other words, the use of a convex mirror *increases the field of vision*. As is evident from Fig. (3-3), light in the arc from *A* to *B*

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*The distance as well as the speed of an approaching object are better judged with the help of a plane mirror.

can reach the eye form the convex mirror, from C to D arc from a plane mirror and only from E to F arc from a concave mirror.

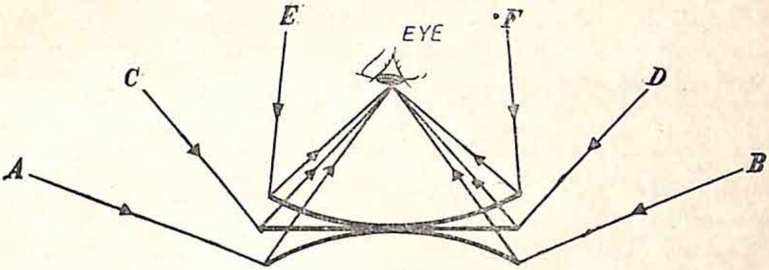

Fig. 3-3

36. *Why does not a truely spherical concave mirror produce perfectly parallel rays of light ?*

Ans. It is owing to a defect known as *spherical aberration* which is the inability of a spherical mirror to focus accurately at its focus all the rays parallel to its principal axis.

[A parabolic mirror can affect this, and is thus used in searchlights and optical devices where a truly parallel beam of light is required].

37. *What is the difference between the aperture and the relative aperture of a spherical mirror ?*

Ans. *Aperture* is measured in terms of the diameter of a mirror. It is also the angle subtended at the centre of curvature by two extreme radii on the principal section of the mirror.

Relative aperture is the ratio of the diameter of the mirror to its focal length.

38. *Suppose we set an object-pin and an image-pin in the no-parallax position w.r.t. a concave mirror. What will happen to the no-parallax position if the whole apparatus is now placed inside water ?*

Ans. The no-parallax position will remain *unchanged.* The focal length of the mirror does not depend on the surrounding medium ; it will remain the same whether the mirror is surrounded by air or any other transparent medium. Evidently, u and v will also have the same values.

39. *Will there be any change in the no-parallax position if we use a coloured pin instead of a white pin ?*

Ans. There will be no effect in the case of a concave mirror as there is no refraction taking place. The focal length of a mirror does not depend on the colour of the pins.

The case will, however, be different in the case of a convex lens due to refraction.

40. *On what factors does the refractive index of a material depend ?*

Ans. (*i*) *Nature of the material.*

(*ii*) *Nature of the medium* in contact with the material.

(*iii*) *Wave-length* or *colour of light* since μ increases with decrease in wave-length. It is maximum for violet light and minimum for red light.

(*iv*) *Temp.* since μ decreases with the rise in temp. But the ratio $\frac{\mu-1}{d}$= a constant where d is the density of the medium.

41. *Why does a sheet of ground glass become almost transparent when wet?*

Ans. Ground glass is made by rubbing the surface of plane glass with a sand-paper. Its surface is thus rendered rough. When the light falls on this rough surface, it is irregularly reflected as well as irregularly refracted. It results in making a sheet of ground glass translucent. But when it is wet, water fills the cavities of its rough surface which then starts behaving like a plane glass and therefore most of the light can pass through it.

42. *An optical medium is either transparent, translucent or opaque. Are these terms absolute or relative?*

Ans. These terms are *relative.* There is no hard and fast rule for such a division because the same medium can be any of them depending upon its thickness. For example, a thin layer of water is transparent, a slightly thicker layer is translucent while an enough thick layer is opaque. We can also cite the example of thin gold leaves.

43. *What will you see when you look at a piece of fused quartz submerged in oleic acid?*

Ans. Fused quartz and oleic acid both have the same refractive index and both are colourless. Since light will pass through their interface without being refracted or reflected, there is no way of seeing the quartz at all.

[**Note** : For the same reason :

(*i*) fragments of glass cannot be seen when submerged in cedar wood oil ;

(*ii*) a truly **invisible man** would have to be colourless and transparent with a refractive index equal to that of air. But the invisible man would also be blind since the lenses in his eyeballs would not form any image on the retina.]

44. *How can you measure μ of a precious stone?*

Ans. Immerse this stone in mixtures of various oils and go on changing the proportion of the oils till the stone is invisible. This is possible only when the refractive index of the stone is equal to that of this mixture of oils. Then measure μ of this mixture.

45. *In what medium can rays of light be curved?*

Ans. If the refractive index gradually rises, the angle of refraction correspondingly decreases. If the ray of light passes through a large number of such thin laminas with a gradually changing refractive index, the ray's path will be curved. Media of this kind are, for example, non-homogeneous liquids or layers of the atmosphere of gradually changing density causing mirage and looming.

46. *Why are multiple images formed by a thick plane mirror? (b) And why is the second image brightest?*

Ans. (a) : If we place a lighted candle A in front of a thick mirror MM' and look obliquely, we shall see several images A_1, A_2, A_3, etc. (Fig. 3-4). These are formed by the repeated reflections from the front surface MM and silvered surface $M'M'$. Since the normal ray AN after reflection on MM or $M'M'$ will be reflected back along the same path, all the images will be formed on this normal line ANN' itself.

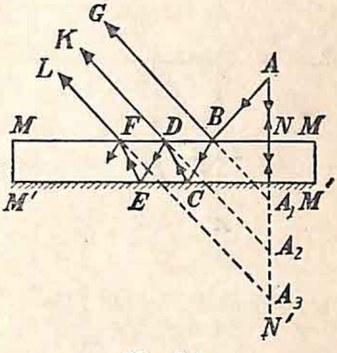

Fig. 3-4

The first image A_1 is formed by a small part of the light which is reflected along BG from the front surface MM of the mirror. Most of the light passes through the front surface along BC and is reflected along CD from the back or silvered surface $M'M'$. Most of this light is refracted along DK, giving rise to the second image A_2 while a small part of the light is reflected back along DE from the lower surface of MM. This DE will be reflected along EF from $M'M'$, will be mostly refracted along FL giving rise to the third image A_3 and a small part will be reflected again at MM. This will continue. As successive reflections take place, the light goes on decreasing in intensity.

(b) : The second image is the brightest because maximum refracted as well as maximum reflected lights participate in its formation.

47. *If the light from an electric filament be reflected from a slab of red glass, two images are seen—one white and other red. Why and how?*

Ans. Refer to Fig. (3-4) of Q. 46 above.

From the front surface MM of the slab of red glass, we get two reflected rays of white colour corresponding to the ray AN of normal incidence and the ray AB since no dispersion can take place. These two reflected rays are responsible for the white image A_1.

When the white light of the electric filament passes through the red slab, all other colours except red are absorbed by the slab. Consequently, the refracted ray BC will be red and it will be reflected along CD and then refracted finally along DK. This ray along with the refracted ray ANN' of normal incidence produces a red image A_2.

49. *Why is it that a pond of clear water appears less deep than it really is* (**or** *why can't a fish under water be shot by aiming straight from an inclined direction*) ?

Ans. This is due to the refraction of light from denser to rarer medium, which bends away from the normal. When the fish A is actually at the bottom of the pond of water, it appears at B because the refracted rays ON and $O'D$ (corresponding to the incident rays AO and AO') appear to diverge from B (Fig. 3-5). Here real depth is OA and apparent depth is OB.

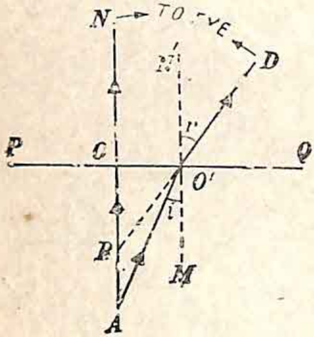

Fig. 3-5

It is also evident that the fish A can not be shot by aiming along $DO'B$ direction.

[**Note** : (*i*) In *Dropadi's Swayamber*, only Arjuna succeeded in aiming at the eye of the revolving fish by directing his arrow along the normal ON while seeing vertically downwards on the image A of the eye of the fish produced by reflection on the oil-surface PQ.

(*ii*) Our finger of length OA appears shorter, of length OB, when dipped vertically in water.]

50. *Why does a straight stick appear bent when dipped partly and obliquely in water ?*

Ans. When a st. stick AOB is immersed in water obliquely and viewed from the rarer medium of air, the rays starting from the lower end B go away from the normal after refraction and enter the eye. These refracted rays appear to diverge from P (Fig. 3.6). Thus the image P of object B is formed somewhat above it. Same consideration applies to every part of OB which appears to take the position OP. Thus the st. stick AOB appears as AOP, bent upwards at the point of immersion O.

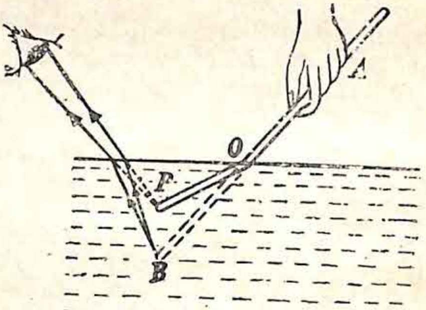

Fig. 3-6

[**Note** : An object under water appears to be raised up more and more when observed more and more obliquely. Keeping the eye on the central line of a vessel containing water, the marginal rays coming from the farthest end of the bottom are raised more than the central rays and therefore *the bottom of a vessel filled with a liquid appears concave when viewed from above.*]

51. *What will happen to the apparent thickness of a glass slab when viewed in red light instead of blue light?*

Ans. It will *increase*. The reason is that for any transparent medium, its refractive index

$$\mu = \frac{\text{real thickness}}{\text{apparent thickness}}$$

Since, real thickness of the given slab is constant while μ for red light is less than that for blue light, hence apparent thickness will become more for red light.

52. *A fish swims in a glass tank. A person, whose eye is above the level of the water, sees two fishes. How is it possible?*

Ans. The fish A is in the glass tank. It is in a denser medium while the eye is viewing it from a rarer medium of air. When a ray is refracted in a rarer medium, it bends away from the normal. One beam of ray starts from the fish A and strikes the side PS of the tank. This beam on entering into air bends away from the normal and strikes the eye of the observer as a diverging beam which on producing backwards appears to diverge from B - thus giving one image B of the fish (Fig. 3-7).

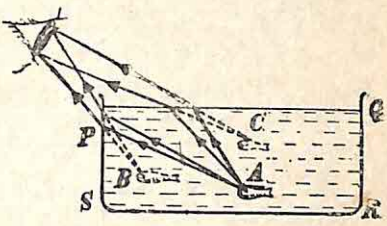

Fig. 3-7

The other image C of the fish A is visible to the eye on account of the rays striking the surface PQ of the water and after refraction they appear to diverge from C as before.

53. *Why does a fish under the surface of water not try to catch a fly flying near the surface of water?*

Ans. Here the object is in air and is viewed from a denser medium of water. We know when light travels from a rarer to a denser medium, the refracted ray bends towards the normal. When the fly is actually at the position A, it appears to the fish at B because the refracted rays ON and $O'D$ (corresponding to the incident rays AO and AO' respectively) appear to diverge from B (Fig. 3-8). Here real height is OA and apparent height of the fly is OB. Since to the fish, the fly A appears to be further away at B, so the fish does not try to catch it.

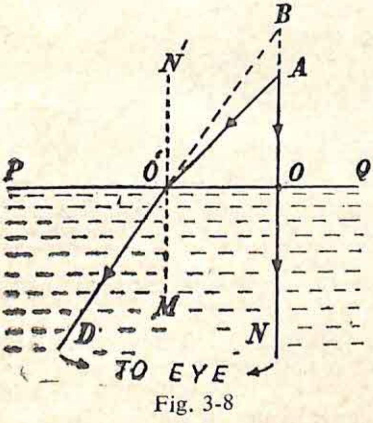

Fig. 3-8

[**Note**: Since an *aeroplane* is

flying in a rarer medium as compared to that of the observer standing on earth, the aeroplane appears higher than its actual position. But here the density of air goes on changing as we go upwards, so we can treat the aeroplane problem like the one in Q. 54 below.]

54. (*a*) *How do the stars appear at the higher altitude* ? (*b*) *And how do they twinkle* ?

Ans. (**a**) : The atmosphere acts as a non homogeneous medium whose refractive index goes on increasing as we come towards the earth. The lower layers of air are denser than those higher up due to pressure of the layers above. Such a medium refracts the successive rays more and more towards the normal so that their path in the atmosphere becomes curved and ultimately these rays fall on the eye. [We know that initially the rays coming from the star S will follow a rectilinear path before reaching the earth's atmosphere shown divided up into layers of different refractive indices]. On producing back the final rays, the star S appears at S' to the eye. Thus we see the virtual image of the star higher up or at higher altitude (Fig. 3-9).

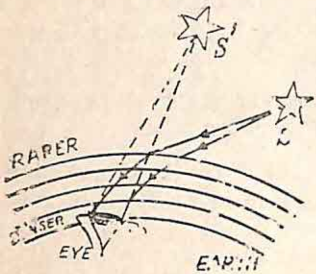

Fig. 3-9

(**b**) : Since these layers of air are in motion due to convection currents, it results in the change of the path of the rays. Thus sometimes more rays fall upon the eye so that the star appears brighter while sometimes only a few rays or no rays reach the eye so that the star appears to be fainter or to disappear altogether. This explains why the stars twinkle or scintillate.

[**Note** : *Planets do not twinkle* on account of their proximity to the earth. They subtend larger angles at the eye, and shine more steadily.]

55. *Why is the apparent day longer than the real day** ?

Ans. Before the sunrise or after the sunset, when the sun S is below the horizon AOD, its virtual image S' is visible to the eye at O (Fig. 3-10). This results in lengthening the day by nearly 2 minutes in the morning and 2 minutes in the evening. In the absence of the atmosphere, the real day would have been nearly 4 minutes shorter.

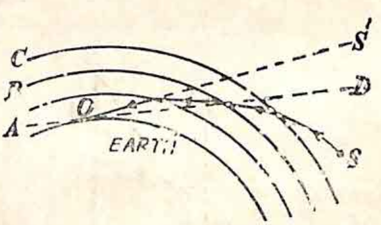

Fig. 3-10

56. *Why do the sun and moon appear as if flattened into oval form when seen near the horizon* ?

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*Another reason is that it also takes 8·25 minutes before the last ray from the sun reaches us.

Sun will be visible in its true position only at midday.

Ans. Refraction in the earth's atmosphere of the sun's (or moon's) rays which come from the ends of the horizontal diameter of the sun's disc (these rays being parallel to the plane of the visible horizon of the observer A) takes place under identical conditions. Therefore we do not notice any distortion of the sun's disc in the horizontal plane.

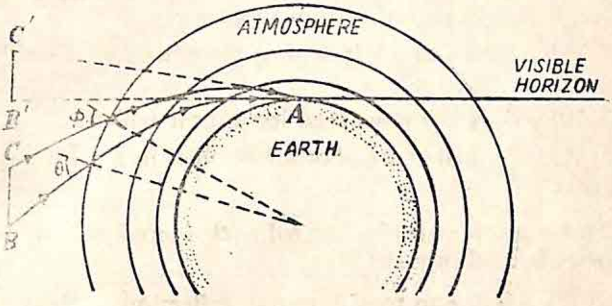


Fig. 3-11

But the rays which come from the ends of the diameter BC of the sun's disc are perpendicular to the plane of the visible horizon (Fig. 3-11). When the observer A sees the lower edge B of the sun's disc, the rays from B strike the upper edge of the atmosphere at a greater angle (say θ) than the rays which come from the upper edge C of the sun's disc ($\theta > \phi$). Therefore they are bent more sharply than the latter while gradually passing through the non-homogeneous medium of the atmosphere (its refractive index goes on increasing as we go towards the earth). As a result, the lower edge of the sun's disc appears to us to be raised higher than the upper edge is raised. Thus the vertical diameter BC appears as $B'C'$. This results in the sun (or the moon) appearing oval or to be flattened in this plane.

[**Note** : When the sun is near the horizon, its rays have to travel a longer path than when it is at noon. On account of greater refraction, the sun appears bigger at the sunrise or sunset than that at noon.]

57. *A ray of light falls on a transparent homogeneous sphere and passes into it. After passing through the inside of the sphere, it reaches the sphere-air surface at A (Fig. 3-12-a). Can total internal reflection take place at this point ?*

Ans. When a light ray PQ strikes the sphere of centre O at an angle i, it is refracted at an angle r and enters the sphere along QA (Fig. 3-12-b). Since $OQ=OA$, therefore $\angle OAQ=\angle r$ also. On account of the reversibility of the path of rays of light and the two angles (r and r) being equal, it (*i.e.* the ray QA) is of necessity refracted and leaves the sphere along AR at an angle i. [Of course, a small part of the light will be reflected back inside the sphere at (**b**) : If the test-tube is filled with water (or is kept vertical), the bright silvery surface disappears at once because light will pass through the water of the tube and there will be no total internal reflection.

[**Note** : *Similarly we can explain the following* :

(*i*) Why does the surface of water in a tumbler, when viewed from below, look like mercury from most angles ?

(*ii*) Why does a crack in a glass pane have a metallic appearance ?

(*iii*) Why does the powdered ice appear white ?

(*iv*) Why do water drops or air bubbles in a glass paper-weight appear silvery ?]

60. *Why does a metal ball coated with lamp-black appear silvery white when immersed in water ?*

Ans. This is due to total internal reflection. Since the lamp-black or the soot does not allow water to come in contact with the surface of the ball, so a thin layer of air is entrapped between the two. The light travelling from water to the ball then will suffer total internal reflection on air-layer. As a result the ball appears white.

61. *How will you explain the brilliancy of diomands ?*

Ans. It is due to total internal reflection which takes place under two conditions : (*i*) light must travel from the denser to the rarer medium, and (*ii*) the angle of incidence must be greater than the critical angle for two given media.

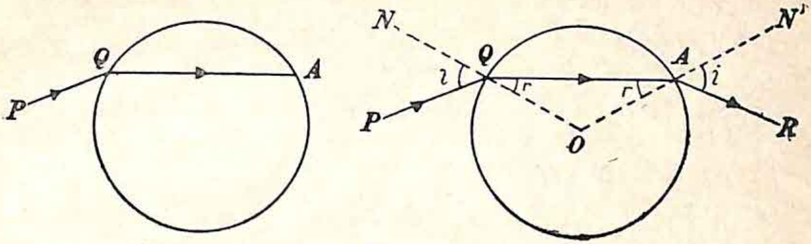
Refractive index of diamond is 2·417, which gives its critical angle θ (given by $\sin\theta = 1/\mu$) equal to 24°. The diamond is cut in such a way that it has many faces so that the light entering through one face is almost always incident on another face at an angle greater than 24°. Evidently the light suffers total internal reflection at various faces one after another till it comes out of one face (when the angle of incidence is less than 24°) as a bright beam of light—making the diamond to shine brightly.

62. *In what direction must a fish in water look to see a rising or a setting sun ?*

Ans. When the sun is rising or setting, the sun-rays are almost horizontal *i.e.* these graze along the surface of water. Thus the angle of incidence at any point of the surface is 90°. The rays of the sun will be refracted inside towards the eye of the fish at an angle of refraction r which equals the critical angle for water and air. Taking μ for water $=4/3$, we have

$$\sin r = \frac{1}{\mu} = \frac{1}{4/3} = 0{\cdot}75 \; ; \qquad \text{or} \qquad r = 48° \, 36'$$

point A and the emergent ray AR will be somewhat less bright.



(*a*) Fig. 3-12 (*b*)

58. *On warm sunny days, tarmac roads often appear to be covered with pools of water some distance ahead, which disappear when approached. How do you explain this ?*

Ans. This phenomenon is due to *total internal reflection* and is similar to a *mirage* which generally occurs in deserts and hot lands in summer. It is an optical illusion.

On warm sunny days, the tarmac roads get heated. The layer of air in contact with the earth's surface becomes very hot and as such density and hence refractive index of air increases from the lower towards the upper region. The rays of light from the sun pass through the denser to the rarer medium (or layers) of air and are bent away from the normal. This continues till the angle of incidence exceeds the critical angle, resulting in the total internal reflection. Due to total reflection, an observer will get sharp light on his eyes from this layer, giving a feeling of watery* surface on the roads.

[**Note** : In the polar regions where it is very cold or near sea-shore in winter season in the morning, *inversion* will occur in the opposite manner on account of total internal reflection and the objects will appear as if hanging upside down higher up in air. This optical illusion is called *superior mirage* or *looming* or *fata morgana* or *Gandharva Nagar*.]

59. (*a*) *Why does an empty test tube held obliquely in a beaker of water and looked from above, appear to be full of mercury ?* (*b*) *Why does this brightness disappear when the test tube is filled with water ?*

Ans. (**a**) : This is due to total internal reflection. The rays of light coming from outside fall on the immersed portion of the tube at an angle greater than the critical angle (=about 42°) between glass and air. Evidently, the rays of light cannot enter into the air of the test tube but are totally reflected. As the air in the test tube acts as a mirror reflecting the rays upward, the immersed part of the test tube, on account of brightness, appears to be full of mercury.

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*A small mirage can sometimes be seen on a hot day by an observer approaching the top of a hill along a tarred road. With the sky as a background, there appears to be a pool at the top of the hill.

Hence the fish must look in a direction making an angle of 48° 36′ with the normal in order to see the rising or setting sun.

63. *How is the covered print not visible from any of the four sides of a glass cube (or slab) placed on a book ?*

Ans. In Fig. (3-13), *ABCD* is a glass cube placed over a book *PQ* and let us consider a letter *E* for its minimum angle of incidence (=0°) and maximum angle of incidence (=90°). There will be a thin layer of air between the book and the cube.

A normal ray *EF* continues to move along the same straight path *EFGH* and does not deviate towards the side *BC* or *AD*.

Another ray *EK* grazes along the surface *CD* and is incident at an angle of 90°. Since the critical angle for glass and air is about 42°, therefore the ray *EK* is refracted along *KL* having 42° as the angle of refraction. This ray *KL* strikes the side *AD* at an angle of 48° which is greater than the critical angle of 42°. Hence *KL* ray is totally reflected along *LM* and finally emerges out of the top side along *MN* or *MG*.

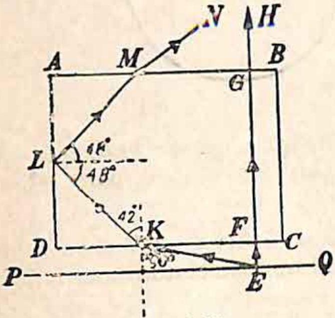

Fig. 3-13

For any other ray from *E*, angle of incidence will be less than 90°, the corresponding angle of refraction will be less than 42° so that the refracted ray will strike the side *AD* at an angle greater than 48° and hence will also be totally-reflected. Thus no ray from *E* emerges out of the side *AD* or *BC* and same consideration applies to the remaining two sides also. Hence the reason.

[**Note** : *Try this yourself* : With a coin underneath a small empty beaker in an evaporating dish, the coin is visible through the sides of the beaker. But when the beaker is filled with water and the top of the beaker is covered with a cardboard, the coin disappears.]

64. *How can a prism serve the purpose of a (a) plane mirror*[*] *(b) convex lens ?*

Ans. (a) : This is possible when it is a *right-angled isosceles prism*. The critical angle of glass w.r.t. air is about 42°. Therefore the ray of light falling normally on any one of the two equal sides of such a prism will enter straight and strikes the third side *AC* at an angle of 45° which is greater than 42°. Thus the ray is totally reflected from *AC* (that is why such a prism is called a *reflecting prism*) and comes out of the other side of the prism normally (Fig. 3-14-*a*). Thus the prism acts as a plane mirror.

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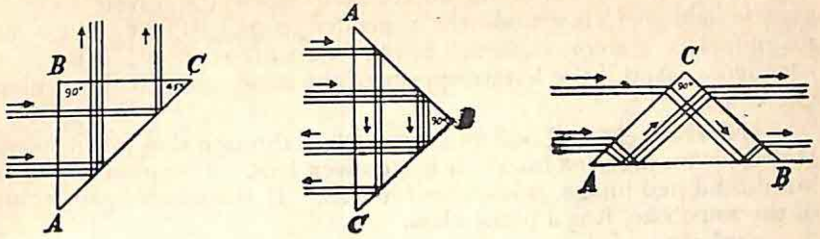
[*] The prism has no metal surface to be protected against tarnishing. That is why the life of a prism is longer than that of a mirror.



(*a*) (*b*) (*c*)

Fig. 3-14

(**b**) : The rays of light can also be made to suffer a deviation of 180° so that the inverted object appears erect (Fig. 3-14-*b*, *c*). That is why a right-angled isosceles prism is called an *erecting prism* and serves the purpose of a convex lens.

[**Note** : The angular deviation of a beam of light by a narrow prism is measured in *centrad* units. One centrad$=0{\cdot}01$ radian.]

65. *If the angle of the prism be greater than twice the critical angle of glass of which it is made, there will be no emergent ray. How will you justify this ?*

Ans. Maximum value of angle of incidence is 90°, *i.e.* grazing incidence. In that case, the angle of refraction (r_1) will be equal to the critical angle (θ) and the refractive index (μ) of the prism material will be given by

$$\sin 90°/\sin r_1=\mu \quad \text{or} \quad \sin r_1=1/\mu$$

$$\therefore \qquad r_1=\sin^{-1}(1/\mu)=\text{critical angle } \theta$$

If A be the angle of prism and r_2 the angle of refraction on the other surface of the prism, then

$$r_1+r_2=A$$

If $A>2\theta$ or $(r_1+r_2)>2\theta$ or $(\theta+r_2)>2\theta$ or $r_2>\theta$

Thus the refracted ray strikes the second surface at an angle r_2 which is greater than the critical angle θ, therefore it will suffer total internal reflection. Hence there will be no emergent ray from the second surface of the prism.

66. *How will you judge whether a given piece of glass is a convex lens, a concave lens or a plane glass ?*

Ans. This can be judged with the help of any of the following three methods* :

Method (i) : Roll a pencil over the given piece. If it touches the piece evenly, it is a plane glass. If it touches the central part but not the edges, it is a convex lens. If it touches the edges but not the central part, it is a concave lens.

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*Students are advised to write only one method and preferably (*ii*) or (*iii*) method.

Method (ii) : Note the observation when the given piece of glass is held very close and over a printed page. If the letters are magnified, it is a convex lens. If the letters are reduced, it is a concave lens. And if the letters appear of the same size, it is a plane glass.

Method (iii) : Look at a distant tree through the given piece. If you see an inverted image, it is a convex lens. If you see an erect but diminished image, it is a concave lens. If the image is erect and of the same size, it is a plane glass.

67. *What are conjugate foci ? For which mirrors and lenses do they exist ?*

Ans. These are a pair of points (and many such pairs will exist) on the principal axis of mirror or lens such that the object placed at one of them produces an image at the other point. The positions of the object and its image can be interchanged at such points.

Conjugate foci can occur in the case of real images only. Hence they exist in the case of concave mirrors and convex lenses, but not in the case of convex mirrors and concave lenses.

68. *What should be the minimum distance between the object and its real image for a convex lens ?*

Ans. (i) : Here we have to find the minimum value of $(u+v)$ when both of them are +ve and hence their product will also be +ve. Using the lens formula $1/v+1/u=1/f$, we get

$$uv=(u+v)\,f \qquad \ldots(i)$$

or $$u^2v^2=(u+v)^2 f^2$$

or $$u^2v^2-4uvf^2=(u+v)^2 f^2-4uvf^2$$

$$uv(uv-4f^2)=(u-v)^2f^2=+\text{ve quantity}$$

$$\therefore \quad (uv-4f^2)\geqslant 0 \qquad (\because \ uv \text{ is also +ve})$$

Using equation (i) : $(u+v)f-4f^2\geqslant 0$; or $(u+v)\geqslant 4f$

$\therefore$ *Minimum value of* $(u+v)=4f$

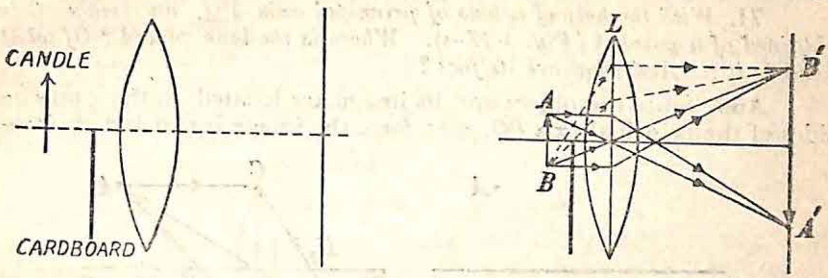
Ans. (ii) : Formula for the displacement method is $f=\dfrac{l^2-d^2}{4l}$.

The least value of the displacement (of the lens) d can be zero and therefore the least value of l, the distance between the object needle and image needle is given by

$$f=\frac{l^2-0^2}{4l}=\frac{l}{4}\ ; \text{ or } 4f=l$$

69. *An image of a candle is obtained on a screen with the aid of a double convex lens. How will this image be altered if the lens be half covered by a piece of cardboard (Fig. 3·15-a).*

Ans. Let us construct the image of the candle AB, obtained on a screen by using the lens L (Fig. 3-15-b). For this purpose we usually take two rays from A as well as from B – one ray passing through optical centre continues to go straight while the other ray being parallel to the principal axis passes through the focus of the lens after refraction. Thus we get the image $A'B'$ on the screen. But it is clear that at point B' (for example) meet not only the two rays, which leave B, already mentioned, but the whole cone of rays which proceeds from B and strikes the lens (two of these rays are shown in the figure as dotted lines). Therefore, if half the lens is covered by a piece of cardboard, rays will still strike the screen from every point of the object, *i.e.* in this case too a *full image* of the object will be obtained. But the amount of rays will be twice as few and therefore the *image will be half as bright.*



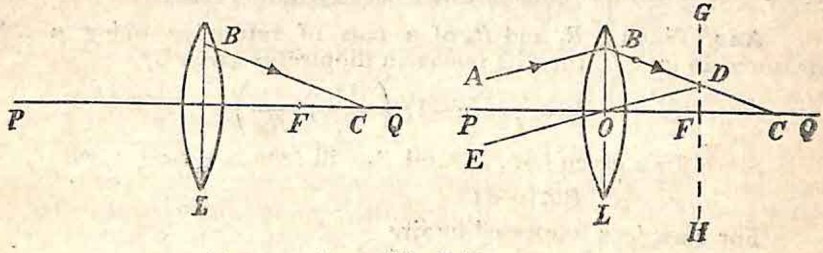
(a) Fig. 3·15 (b)

70. *In Fig. (3-16-a) is depicted the path of a ray of light BC, after refraction in a double convex lens L of principal focus F and of principal axis PQ. What is the path of this ray before reaching the lens ?*

Ans. For this purpose, we shall use two basic properties of a lens :

(1) A ray of light that passes through the optical centre of a lens continues its straight journey.

(2) All the rays which strike a lens in a parallel beam, converge at one point, after refraction, in the focal plane of the lens.



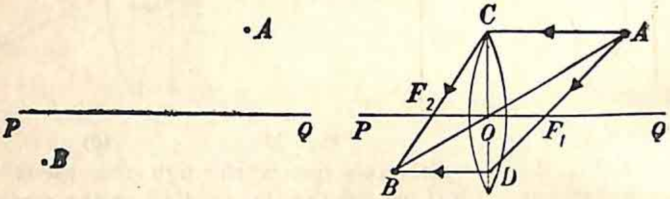
(a) Fig. 3-16 (b)

Now draw the focal plane GFH which cuts BC at D (Fig. 3-16-b). Draw any ray EOD passing through the optical centre O. Using the property (2) of the lens given above, the unknown ray of light must be parallel to the ray EOD and strike the lens at B.

Draw a line *AB* parallel to *EOD*. Then the line *AB* represents the path of ray *BC* before it is refracted in the lens.

71. *With the help of a lens of principal axis PQ, an image B is obtained of a point A (Fig. 3-17-a). Where is the lens placed ? Of what kind is it ? And what are its foci ?*

Ans. Since the object and its image are located on the opposite sides of the principal axis *PQ*, therefore, the image is real and obviously obtained with the help of a *double convex lens*. Evidently the st. line *AB* cuts *PQ* at the optical centre *O* of the lens (Fig 3-17-*b*). Erect the perpendicular to *PQ* at *O* and draw a ray *AC* ∥ *PQ*. After refraction in the lens, this ray must pass through the second principal focus F_2 of the lens and strike the point *B*. Thus the point of intersection of *CB* and *PQ* gives the location of focus F_2. By drawing a line *BD* ∥ *PQ* and then joining *D* and *A*, we get the first principal focus F_1 where *DA* cuts *PQ*.



(*a*) Fig. 3-17 (*b*)

72. *Will the focal length of a lens change when it is dipped in water ?*

Ans. *Yes.* The focal length of a lens depends upon the relative refractive index of the material of the lens and its surrounding medium given by $\frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$ where R_1 and R_2 are radii of curvature of the two surfaces of the lens. If the surrounding medium is changed, the focal length will also change.

73. *A convex lens of glass is immersed in water. Compared to its power in air, will its power in water increase or decrease ?*

Ans. When *f*, R_1 and R_2 of a lens of refractive index μ are measured in metres, then its power in dioptres is given by

$$P=\frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$$

Since for a given lens, R_1 and R_2 will remain constant, so

$$P \propto (\mu-1)$$

For glass-lens immersed in air,

$$P_{ga} \propto ({}_a\mu_g-1) \propto (1{\cdot}5-1) \propto 0{\cdot}5$$

And for glass-lens immersed in water,

$$P_{gw} \propto ({}_w\mu_g-1) \propto \left(\frac{{}_a\mu_g}{{}_a\mu_w}-1\right) \propto \left(\frac{3/2}{4/3}-1\right) \propto 0{\cdot}125$$

Hence its power in water will *decrease* as compared to that in air.

74. *Under what conditions can a convex lens act as a concave lens and vice versa ?*

Ans. If a lens is dipped in a medium which is optically denser than the lens itself, then its properties will get reversed. For example, if we immerse a concave lens in carbon disulphide ($\mu = 1{\cdot}63$), it will behave like a convex lens and a convex lens in the same medium will behave like a concave lens.

75. *How are "invisible windows" prepared ?*

Ans. The windows are made of cylindrically curved glass arranged so that the reflections from the sky or street lighting are directed down away from eyes of shop-gazers. The appearance is then that of a shop-front without a window.

76. *What will be the appearance on the screen if the slide and the projection lens are removed while the projection lantern is still in action ?*

Ans. Since the condensing lens is at a distance slightly more than its focal length from the projection lamp, the light from the lamp, after passing through the condensing lens will converge and then diverge – thus forming a circular spot of light on the screen.

77. *How does a telescope enable us to see distant objects invisible to the naked eye ?*

Ans. It is because the instrument (*i*) gathers together by refraction more luminous rays of light from the distant or obscure objects than our eye can, and (*ii*) focusses them into one small image, where they are magnified by the eye-piece of the telescope and thus seen by our eye.

78. *What alteration in an Astronomical Telescope is required to increase (i) magnification (ii) brightness of image ?*

Ans. (**i**) : For an astronomical telescope, we know that

$$\text{magnification } (m) = \frac{\text{focal length of objective}}{\text{focal length of eye-piece}} = \frac{F}{f}$$

i.e. $m \propto F$ and $m \propto 1/f$

Hence it is clear that the magnification of the telescope can be increased by increasing the focal length F of the objective lens and by decreasing the focal length f of the eye-piece.

(**ii**) : The brightness of the image can only be increased by gathering more and more light from the object And that is possible by increasing the diameter or size of the objective lens.

79. *If you are supplied with four convex lenses of focal lengths 100, 25, 3 and 2 cm. respectively, state which lenses you would select for constructing (a) a Compound Microscope, (b) an Astronomical Telescope ?*

Ans. (**a**) : For a Compound Microscope*, we know that its

$$\text{M.P.}=\frac{v}{u}\times\left(1+\frac{D}{f_e}\right)=\frac{L}{f_o}\times\frac{D}{f_e}$$

The magnifying power will be large, if

(*i*) u is small, *i.e.* when the focal length (f_o) of the objective is small.

(*ii*) v is great, *i.e.* the object is placed very near the focus of the objective lens.

(*iii*) f_e of the eye-piece is small.

(*iv*) tube-length (L) is large.

Considering (*i*) and (*iii*), we must take two lenses, one of focal length 3 cm. for eye-piece and another of focal length 2 cm. for objective lens.

(**b**) : We know M.P. $=F/f$ for an astronomical telescope.

To increase M.P. of an astronomical telescope, F should be large and f should be small. Therefore we must select lenses of focal length $F=100$ cm. for objective lens and $f=2$ cm. for eye-piece.

80. *Some persons use two pairs of glasses, one for seeing at a distance and other for reading. Why ?*

Ans. People use spectacles to assist their sight, which may be defective from various causes. Concave lenses are used by a myopic eye *i.e.* for seeing the distant objects clearly while convex lenses are used for hypermetropic eye *i.e.* for seeing the nearer objects clearly.

Generally older people lose the power of accommodation of the crystalline lens of the eye. As a result, the near point recedes beyond normal distance of distinct vision of 25 cm. This defect is called *Presbyopia*. It can be remedied by using two pairs of spectacles *i.e.* convex-lens spectacles for seeing nearer objects and concave lens spectacles for seeing distant objects.

81. *As we have two eyes and each perceives a separate image, how is it we do not see any thing double ?*

Ans. When an object is seen distinctly with both eyes, the axes of both are directed to it and the object appears single. Moreover, the two optic nerves, both leading to the same point in the brain, excite but one sensation. Since one eye sees more of right side of the object clearly and the other eye sees more of its left side clearly, it produces three-dimensional effect. [Also, seeing the same object with both eyes at once enables us to judge more accurately its distance than if we see it with only one eye.]

[**Note** : Wonderful as our sight is, the brain does sometimes deceive us about what we see. If we receive a blow on the eye, our brain tells us that we *"see stars"*. The blow stimulates the sensory nerve cells and so produces a picture of something that is not actually there.]

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*Compound microscope is so called as the magnification occurs in two stages, once by the objective lens and the second time by the eye-piece.

82. *Why do light areas always seem bigger than dark areas of equal size ?*

Ans. This is on account of imperfection of our eye whose refrangible media do not caste on the retina that sharply-etched outline which one gets on the ground glass screen of a well-focussed camera. Owing to spherical aberration, every light patch has a light fringe which enlarges the retinal image.

[**Note** : Similarly answer the following :

(*i*) *Why do you appear slimmer in dark dress than in clothes of light tones ?*

(*ii*) *Why does a crescent moon seem part of a circle the diameter of which is larger than that of moon's dark portion ?*

(*iii*) *Why does a rising or a setting sun seem to make a depression in the horizon ?*]

83. *When you turn round quickly several times and then suddenly stop, you feel giddy. Why ?*

Ans. You feel giddy and your muscles seem to be urging you to fall down because the liquid in the canals continues to rotate after you stop, and thus a confused message suggesting that you are still turning is sent to your brain and from there to your muscles.

[**Note** : Repeat the above experiment but immediately on ceasing to turn, quickly jerk your head in the opposite direction. This will help to restore your sense of balance.]

84. *When a table fan is running at a high speed, to a person looking at its revolving blades, it appears that a solid disc is revolving instead of the blades. Why ?*

Ans. This is due to the *persistence* of vision.* When an impression is formed on the retina, the sensation persists for some time, nearly 1/10 of a second, even after the object is removed. If the individual impressions fall on our retina in a time less than 1/10 of a second the object could not be identified by the eye separately, as in the case of revolving blades of an electric fan. When the speed is slowed down, the blades could easily be distinguished.

[**Note** : Even through revolving blades, we can see the objects on the other side, though dimmer but without flicker. Same consideration applies *when two express trains pass from opposite directions and a passenger can see the landscape through the other train.*]

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*A spectrum of white light is obtained on a screen which is rapidly swung to-and-fro along the line of colours of spectrum. Due to persistence of vision, the eye sees a white band on the screen fringed with red at one end and violet at the other since no other colours reach the two ends.

85. *When a wheel is in motion, the upper spokes often seem to merge while the lower ones are distinct. Why is it so ?*

Ans. When a wheel is rolling, it is turning, at every moment, about its point of contact with the earth. Therefore the linear velocities of its upper spokes are greater than those of its lower ones which are placed nearer the point which is stationary at any given moment.

86. *Why is it that when a car is moving forward on a cinema-screen, the wheels often appear to be turning backwards ?*

Ans. This phenomenon is to be observed if the speed of change of frames in the film is very slightly greater than the speed of revolution of the car-wheels. Then in the time taken for one frame to succeed another, the wheels have time to perform rather less than one revolution. To the eye, during this interval of change of a frame, the wheels appear to be turning backwards by the amount by which they lack one revolution.

If the wheel has time to perform one full revolution during each change of frame, the wheel will seem to stay still.

87. *Why do we see better when we get used to the dark ?*

Ans. It is because the pupil of the eye dilates and allows more light rays to pass through the aperture. Thus we see more distinctly.

[**Note** : It is on account of the power of considerable enlargement of the pupils of their eyes that cats, owls, etc. can see in almost complete darkness.]

88. *Why does everything appear dark after staring at the sun ?*

Ans. It is because the pupil of the eye is so contracted by looking at the sun that it is too small to collect sufficient light rays from objects to distinguish their colours. Due to high intensity of light received by the retina, its optic nerves get tired and become insensitive to a comparatively much smaller intensity of light getting from other objects.

89. *Why, after looking steadily at a brightly coloured lamp, should a similar image of another colour be perceived when the eyes are quickly turned to a white surface ?*

Ans. It is because the nerves of the eye have been so strongly exercised in perceiving a very bright colour that their sensibility is so diminished that the perfect balance of action necessary to the sensation of white no longer exists. But those elements of sensation, which have not been so weakened, overpower the others, with the result that the after-image is seen as a *complementary colour* to the original.

90. *Of what shape should be the front surface of the cornea of an imaginary animal which could see distant objects equally well in the air and under water without any supplementary accommodation ?*

Ans. For the eye's focal length to remain the same, both in the air and under water, there must be no refraction of rays proceeding from distant objects (*i.e.* parallel rays) on the front surface of the cornea. Therefore this surface must be flat.

91. *Why has Nature endowed man with two eyes when one eye is sufficient to form image of any object ?*

Ans. It is on account of following advantages :

(1) *Field of vision increases* : With one eye we see less area (about 135° range) and with two eyes we see more area (180° range) at a time.

(2) *Correct judgement* of distances* : That is way it is difficult to thread a needle with only one eye open.

(3) *Three-dimensional* (or 3-D) *effect* : The left eye sees more of the right side of the object and the right eye more of the left side. Thus two images of the same object are formed which intermix at the retina and produce the effect of solidity.

92. *Why is a binocular a better aid than an ordinary telescope ?*

Ans. See 3 advantages given in Q. 91 above.

93. *Why are Galilean telescopes used in binoculars ?*

Ans. For the same magnifying power : (*i*) the tube length of an ordinary (or astronomical) telescope is $(F+f)$ and the final image is inverted ; (*ii*) the tube-length of an ordinary terrestrial telescope is $(F+f+4f')$ and the final image is erect, where f' is the focal length of the third convex lens placed between its objective and eyepiece, (*iii*) for final erect image, the tube-length of a Galilean Telescope is $(F-f)$. Since $(F-f)$ can be made as small as one likes, therefore Galliean telescope's tube can be easily managed.

94. *What is the significance of two numbers generally stamped on a pair of binoculars ?*

Ans. The first of the two numbers indicates the magnification and the second gives the diameter of the objective lens in millimetres.

[Thus 8×25 indicates a magnification of 8 and 25 mm as diameter of the objective lens. This system of describing binoculars was introduced between the two World Wars.]

95. *In what way do 3-D films work ?*

Ans. Suppose a photograph is printed in red, and not quite over the top of it the same photograph was printed again in green. When the viewer looks through the pair of red and green glasses, the eye looking through the red glass cannot see the red lines, and the green lines looked black, so a black picture was focussed onto the retina. The eye looking through the green glass cannot see the green lines and the red lines look black, so a slightly different black picture is focussed onto the retina of the other eye. The brain then blends these two pictures to make a solid 3-D picture since the scene is given a depth also.

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*A one-eyed person often pours tea behind or in front of the cup.

[**Note.** (*i*) Different lighting of different parts of objects enables us to perceive the shape of solid objects. (*ii*) Strain we feel when accomodating our eye to get a clear perception of the different distances of an object's different parts also plays a role in getting 3-D effect.]

96. *What is better method of seeing a photograph** ?

Ans. (**i**) : To obtain from a photograph the same visual impression that the photographed object produces, we must

(*i*) look at the photograph with *one eye* only, and

(*ii*) hold it at the *proper distance away* so that you look at the photograph from the same angle of vision from which the camera-lens reproduced the image on the ground glass screen. That is

$$\frac{\text{distance of photo from eye}}{\text{distance between object and lens}}=\frac{\text{size of photo}}{\text{size of object}}$$

This gives the distance of the photograph from the eye to be roughly equal to the focal length of the camera-lens.

Ans. (**ii**) : When you look at a photograph with both eyes, the picture you get is flat and not 3-dimensional. But the photographs taken with a lens having $f=70$ cm. can be looked at with both eyes without losing the sense of depth.

Ans. (**iii**) : The lens of an ordinary camera is of 15 cm. focal length. Enlarge the picture taken by this camera 4 or 5 fold and then you can see it with both eyes from 60 to 75 cm. away.

97. *Which is the best seat in a cinema hall ?*

Ans. The effect of relief is best when we look at the picture from the same angle of vision as the movie camera 'looked' when it was shooting the film. Therefore

(*i*) choose a seat right opposite the middle of screen ; and

(*ii*) $\dfrac{\text{distance of seat from screen}}{\text{screen width}}=\dfrac{\text{focal length of camera lens}}{\text{film width}}$.

98. *In sun glasses, both the surfaces of the glasses used are curved yet they do not behave like a convex or concave lens. Why and how ?*

Ans. In sun-glasses, the outer surface is convex and the inner surface is concave. Hence they possess powers of opposite signs. By making these surfaces of equal powers, the effective power of the combination becomes zero. Hence these glasses behave like a thin glass sheet possessing no converging or diverging power.

99. *State the principles made use of, in the case of the following :*

(*a*) *Projection lantern*; (*b*) *Cinematograph* ; (*c*) *Photographic camera* ; (*d*) *Magnifying glass* ; (*e*) *Prism-binoculars* ; (*f*) *Stereoscope.*

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*Similarly answer "How to look at a painting" ?

Ans. (**a**) : When an object is placed between *f* and 2*f* of a convex lens, its real, inverted and enlarged image is formed beyond 2*f*.

(**b**) : Persistence of vision.

(**c**) : When an object is placed beyond 2*f* of a convex lens, its real, inverted and diminished image is obtained between *f* and 2*f*.

(**d**) : A virtual, erect and enlarged image is obtained of an object which is placed within the focus of a convex lens.

(**e**) : Isosceles right-angled prisms produce total internal reflection.

(**f**) : Three-dimensional motion pictures have been devised with binocular vision and stereoscopic photography.

[**Note** : (*i*) If two photographs of the same object are taken simultaneously by two cameras, whose lenses are placed in the position of the two eyes of a person, a stereoscopic picture can be obtained in three dimensions.

(*ii*) Movies' shots from an express train spring into unusually clear relief just as good as the stereoscope since the foreground has been distinctly separated from the background and this creates the impression of depth.]

100. *Why does a glass slab not produce any spectrum ?*

Ans. A glass slab can be supposed to consist of two similar prisms placed with their refracting edges vertical but turned in opposite directions. Thus the dispersion produced by the first prism is recomposed by the second prism. Evidently, we can not get any spectrum.

[**Note** : In a reflecting prism, the incident light falls normally on the surface so that there is no deviation of path after refraction. Same applies to the emergent rays on the other surface. All colours continue to move along the same path. Hence the emergent rays are not coloured.]

101. *Why is it that dispersion is produced by refraction but not by reflection ?*

Ans Refraction is due to the fact that the velocity of light in an optically denser medium is smaller than that in a rarer medium. This change in velocity, on passing into another medium, is the primary cause of the bending of light [There is no such bending for normal incidence as both angle of incidence and angle of refraction are zero.]

Moreover, lights of different colours have different velocities and hence different refractive indices. Therefore, for the same angle of incidence for white light (composed of seven colours), lights of different colours will be refracted along different paths, causing dispersion.

But in reflection, there is no change of medium and hence lights of all colours continue to move along the same path as a combined beam of light. Hence no dispersion.

102. *Why are the colours of various objects altered when viewed in a coloured light?*

Ans. When illuminated by a red light only, objects normally red in daylight are seen in their true colour, whilst a blue object will appear nearly black because it only reflects blue and there are no waves of light of this colour present to be reflected. The normally blue object absorbs all the red rays emitted from a normal source of white light. The qualities of all colours differ when seen by a coloured light for the same reason.

103. *Why do some transparent substances appear coloured when seen by the transmitted light?*

Ans. A transparent body is coloured if it is more transparent to some coloured rays than others—its colour being that which results from mixing the transmitted rays. No new colour is added by the transmission, but certain colours are more or less perfectly stopped from passing through.

104. *Why, when looking through a piece of red glass and a piece of green glass (held one behind the other), should one see almost black?*

Ans. Red glass transmits light which consists almost entirely of red rays while green glass transmits green rays only. Evidently the transmitted red rays of red glass are not transmitted by the green glass. Thus their combination stops all light passing through the pair. The result is that their pair appears almost black.

105. *Red and green lights when mixed together produce yellow light. How is this different from pure yellow?*

Ans. Pass the two yellow lights through a prism. The first one will split into red and green on a white screen placed on the other side of the prism. The pure yellow light will simply produce a yellow spot on the screen.

106. *Two pieces of yellow glass look alike; but one transmits only yellow light, the other transmits a mixture of red and green. How would you use a piece of pure red glass to identify each of the yellow pieces of glass?*

Ans. Red glass transmits red rays only, yellow glass transmits yellow rays only and green glass transmits green rays only. Light after passing through the piece of pure red glass will consist of red rays only which will be completely stopped by the piece of yellow glass. Hence the combination of red and yellow glasses will appear black. But the red rays transmitted by the piece of pure red glass will partially pass through the other piece of glass and the eye will receive red rays.

107. *A yellow flower appears greenish when viewed in blue light and dark when viewed in red light. Why?*

Ans. A body has no colour of its own. Its colour depends upon the reflected or refracted (or transmitted) light by which we see the body.

A yellow flower not only transmits yellow but a little of green and orange also, its neighbours in the spectrum. Similarly a blue glass allows not only blue but a part of indigo and green also. So in blue light, the yellow flower will appear greenish—a colour which is common to both.

The yollow flower appears dark in red light because yellow colour absorbs the red completely and does not reflect or transmit any colour.

[**Note** : Avoid buying coloured clothes at night. A jersey with green and white strips will appear to have black and yellow strips in yellow light.]

108. *Why does a piece of paper appear white, a rose appear red and a leaf appear green in day-light ? How do you expect them to appear when viewed (a) in green light, (b) in red light, (c) through green glass, (d) through red glass ?*

Ans. We know that a body has got no colour of its own. Its colour depends upon the reflected or transmitted light by which we see the body. In day-light, a piece of paper appears white* because it reflects all the seven colours, and a rose appears red because it reflects the red colour only and absorbs all other colours. Similarly a leaf appears green because it reflects the green colour only and absorbs all other colours.

(*i*) White is no particular colour but the presence of all the seven colours. Therefore, *white paper* will appear green in green light, red in red light, green through green glass and red through red glass.

(*ii*) *Rose* : It will appear red in red light or through red glass, and dark in light of all other colours or through glass of all other colours.

(*iii*) *Green leaf* : It will appear green in green light or through green glass and dark in red light or through red glass.

109. *Why does a washerman give blueing to the clothes ?*

Ans. It is because clothes acquire a yellowish tint after washing with soap. But as blue is complementary to yellow, blueing whitens the washed clothes.

[**Note** : Similarly if a lady has a sallow (*i.e.* pale-brown) or yellowish complexion, she should add a little blue colour to her face powder to neutralize the yellow tint. Some ladies add blueing to hair.]

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*Remember for your own safety : When you are crossing roads on a dark night, it is wise to wear something white that will reflect all the light there is. The motorist will then be able to see you more clearly.

110. *Smoke scatters light towards our eyes even though the light was originally travelling in such a direction that it would not reach us. Then why does a dense cloud of smoke overhead appear dark, rather than light?*

Ans. Whether something appears light or dark depends both on the source of illumination and on the background against which the object is seen. In reflected light, the smoke appears bright against a dark background. The same smoke, however, absorbs some of the light hitting it. If smoke is illuminated from behind, it will then absorb some of the light and appear darker than its back ground.

111. *Why are stars visible during the night and not during the day?*

Ans. During the daytime we do not see the stars because of the atmosphere around the earth. The atmosphere breaks up and scatters the light into a blanket of extreme brightness through which we can not see the distant faint stars. This brilliant blanket is removed during the night, hence the stars become visible.

112. *If there were no atmosphere around the earth, and if life were still possible, what would be the colour of the sky? Would you be able to see the stars then?*

Ans. If there were no atmosphere on the earth, the colour of the sky will be pitch black and the stars will be visible even in day time.

113. *Why does a coloured glass, when powdered, look white?*

Ans. A body appears white when it reflects all the seven colours and black when it absorbs all the colours incident on it and does not reflect or transmit any colour.

Tiny particles of finely powdered glass cannot absorb the incident light but reflect it irregularly in all directions (also known as scattering). Hence, irrespective of the colour of the powder, it appears white in sunlight from all directions.

114. *Why are sunrises and sunsets often reddish in colour?*

Ans. At the sunset or sunrise, when the sun is near the horizon, the rays have to travel and pass through greater depth of atmosphere than when the sun is over the head at noon. As a result, the enormous numbers of minute particles of dust, water vapour and air try to scatter or irregularly reflect the incident white light. But a particle cannot reflect a wavelength greater than its own size. Thus the shorter wavelength colours– blue and violet get scattered while longer wavelength of red colour passes through the atmosphere and reaches our eyes. Hence a beautiful reddish colour is seen at the sunset or sunrise.

[**Note** : There is little air or dust high in space to scatter the blue light, so the sky has no colour and is black. This has been verified by the astronauts flying in space.]

115. *Why is the sky blue?*

Ans. It is because in the sun's light, blue and violet waves are of smaller wavelengths and are easily scattered by the air and by dust particles of the atmosphere, while red waves of larger wavelength can easily pass through these particles. This is why there is a spreading of blue light and the blue appearance of sky.

116. *How does a landscape painter put distance into his pictures?*

Ans. Most of the dust remains in the lower, denser part of the atmosphere, and that is what makes the distant view look bluer or greyer than the foreground. Thus a landscape painter can put distance into his pictures by toning down the background with soft greys and blues.

117. *Why does a deep sea look blue?*

Ans. The blue colour of the deep sea is partly due to reflection of the sky and partly due to scattering of light by water molecules. These particles scatter the shorter wavelength colours – blue and violet which reach our eyes while the longer wavelength colours pass through.

118. *Why is blue glass used in "day-light" bulbs?*

Ans. In day-light or white light, the *three* primary colours (red, green and blue) are equally strong and present in almost equal amount. But in artificial or electric light, the amount of red colour is greater than that of the other two primary colours. A blue glass bulb, surrounding this light, absorbs the excess of red light present in it – so that the transmitted light becomes almost white like that of day-light.

119. *Why should our face and hands assume such a ghastly look when seen illuminated by sodium light?*

Ans. Because this illumination is a monochromatic yellow and all objects so illuminated appear of a uniform colour (that of the lamp light itself) – differing only in brightness or darkness. And moreover those colours which contain no yellow when seen by daylight are changed to black (and shades of grey) in the absence of any reflected colour. The human countenance, being practically devoid of yellow, refuses to reflect yellow and thus appears black (or grey shaded).

[**Note** : *Blue is a cold colour*; therefore it is undesirable to use blue wall-paper, a blue rug, or blue draperies in winter in a room that has a northern exposure. In such a case, yellow or buff colour is preferred.]

120. *If you look at a luminous advertisement (e.g. at a neon sign), the red letters always seem to stick out in front of the blue or green ones. How does this happen?*

Ans. The focal length of the eye, as of any lens, is different for different wavelengths*, *i.e.* for different colours of the spectrum (Fig. 3-18). Red rays are refracted less violently (due to less refrangibility) and therefore the visual impression is caused that red objects are nearer to the observer than blue or green or any other colour ones.

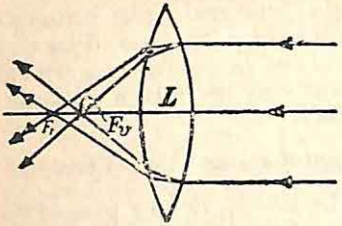

Fig. 3-18

[**Note** : Similarly in a colour painting, red parts stand out.]

121. *Why are the signal lights, indicating danger, red* ?

Ans. According to Helmholtz's Theory of Colour Vision, there are three nerve-endings or cones in the retina which enable us to appreciate colours. Each cone responds to one particular primary colour—red, green or blue.

If all these cones are equally excited, then the sensation of white is produced. When light from any other colour falls on the eye, these cones react to different extents and we see that colour. If one set of nerve-cones be absent or inactive, the person is blind for that colour. Occasionally the green or the blue nerve-cones do not function but the red cones continue to function. This is one reason why signal lights are red.

Moreover, on account of longer wavelength, red colour can penetrate through fog, mist and haze.

Thirdly, red colour is brighter than green or blue, and hence is more easily visible at great distances.

Fourth reason may be the psychological one ; blood is also red.

[**Note** : Fatigue colour is always that colour which, together with the original colour, makes up white.]

122. *How are colours projected in our colour film* ?

Ans. This is done under two systems : (*a*) Additive, (*b*) Subtractive. In the first system additional lenses are put in front of the camera and the projector while in the second system proper colours are put on the film band itself later on.

In the technicolour camera, the beam of light is split up by a half transparent gold prism and these film-bands are exposed simultaneously—one records the blue element of the light beam, second the green and third the red. The three negatives are combined by a series of laboratory processes onto a single film containing all the colours, ready for projection on the screen.

123. *How are colours obtained in colour photography* ?

---

*Wave-length of light and atomic distances are measured in the Angstrom Unit ($=10^{-8}$ cm.) while the nuclear distances are expressed in *fermi* unit ($=10^{-13}$ cm).

Ans. It is also based on the "additive" and "subtractive" systems like the colour film.

In the additive system, three negatives are exposed through filters in the three primary colours (*i.e* green, blue and red) or a mosaic of tiny filters in these colours as a part of the emulsion of a single film or plate. The negative is developed into the positive which can be viewed by holding it against a light or projected onto a screen.

124. *Why are the colours of a secondary rainbow—often seen outside the first always in reverse order ?*

Ans. It is because in the inner (or primary) rainbow we see (standing back to the sun) the spectrum of the sun's rays which enter the top of each rain drop and are refracted from the bottom. But in the outer (or secondary) rainbow we see the sunlight which enters the bottom of the raindrops and is refracted from the top after two reflections inside the drops. The second reflection is responsible for the reverse order of colours.

[**Note** : (*i*) Here it is simple reflection and not total internal reflection, otherwise the light will not come out at all.

(*ii*) Moreover, on account of absorption of light on each reflection, the secondary rainbow is not so bright as the primary rainbow.

(*iii*) The region between the two rainbows is quite dark since the light rays suffer refraction on second (for primary rainbow) or third (for secondary rainbow) encounter with the inner surface of water drop and do not reach our eye.]

125. *It is said that sun contains many of the elements found on earth. How has this been determined ?*

Ans. This has been found from the analysis of the well-known *Fraunhoffer lines* in the solar spectrum.

If analysis of the solar spectrum is made with the help of a spectroscope, one would observe a large number of strong and weak lines. These lines are the Fraunhoffer lines. These lines, in the colour band of the spectrum, represent the different materials in the object producing the light. It has been observed by scientists that any body making similar experiments can observe that each material on this earth has its own Fraunhoffer lines. These same lines are also observed in the solar spectrum. This clearly shows that the sun and stars are made of similar materials and substances as are found on our earth [but stars are surrounded by vapours containing the same substances but at a lower temp. than for the sun].

126. *How is it possible with the help of a spectroscope to distinguish between the incandescent solid particles and a glowing vapour ?*

Ans. The kind of light emitted by incandescent objects depends largely upon the chemical nature of the substances and partly upon its physical state. In general, the spectrum of a glowing vapour shows bright lines on a dark ground, whereas the spectrum of an incandescent mass of solid particles—however small—consists of a continuous band of colours.

127. *Why does a thin oil film appear coloured ?*

Ans. This is due to interference of light reflected from thin films. When light is incident upon a thin film, a part of it is reflected from the upper surface while the rest gets refracted. This refracted light again gets reflected from the lower surface and then gets refracted from the upper surface. These two reflected rays differ in the lengths of their paths. If these lengths differ by half a wavelength, these reflected rays destroy each other and produce a dark band. On the other hand, if these lengths differ by full wavelength, these reflected rays help each other and produce a bright band of colour of the incident light. Thus we get alternate bright and dark bands of colours.

When white light falls on a thin film, on refraction white light breaks up into seven colours and hence we shall see a bright band of seven colours and then a dark band and these will continue to occur alternately.

128. *Why can you not see interference fringes with two separate electric lamps ?*

Ans. An essential condition for observing interference of light is that the light waves coming from two sources must be in the same phase or have a constant phase difference, *i.e.* the two sources must be coherent. This is not possible with two separate electric lamps since they will be in one phase at one moment but get out of plase in no time. The easiest way of getting two coherent sources of light is to make one source the image of the other.

129. *How can the two parallel beams of infra-red and ultra-violet radiations be separated ?*

Ans. Allow the two beams to pass through a quartz prism. The two radiations would deviate differently—the ultra-violet deviating more towards the base of the prism.

[**Note** : By using a rock-salt prism, only infra-red radiations will be obtained as it absorbs ultra-violet radiations.]

130. *Can polarised light be distinguished from common light by the naked eye ?*

Ans. *No.* For all purposes of experiment in polarised light, two pieces of apparatus must be used—one to produce polarisation and another to show it. These are called a polariser and an analyser respectively, and are interchangeable in use.

131. *What is your idea about the speed of light of different colours in vacuum ?*

Ans. The speed of light of various colours in vacuum is the *same* (within the resolving time of the eye). This conclusion is supported by the observation that an explosion of a star in the heaven (producing what is known as a *super nova*) appears as white light and not sequences of coloured flashes. The stars are so far away that the light from them takes many many years to reach us. An explosion that we observe must have occurred a long time ago and the light has been travelling towards us ever since. We see the explosion as a bright white light, not a series of different colours arriving at different times.

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1. *Cathetometer* measures verticalness *i.e.* the state of being vertical.
2. *Chromometer* measures brightness of colours.
3. *Collimator* renders the rays parallel.
4. *Illuminance* is another name for intensity of illumination.
5. *Lux* is the commercial name for a metre-candle.
6. *Magic eye* is another name for a photo-electric cell.
7. *Phot* is the commecial name for a cm. candle.
8. *Photon* is the name of light-particles christened by Newton.
9. *Refractometer* measures the refractive index of a medium.
10. *Stereoscope* is the device to give to the eye the appearance of depth for photographic pictures.

Part IV—Sound

Concise Sound

1. Production and Propagation : Sound is a form of energy and travels as a *wave motion* which arises from the periodic vibrations of a body. It requires a *material medium* for its propagation. The medium must be *continuous* and *elastic*. [**Deaf children** listen to music by resting their hands upon the frame of a piano so that the bones can conduct the sound-waves to the ear].

For the production of sound, the frequency of vibrations must be within the limits of audibility, *e.g.*

20 vibrations/sec. ...(lowest limit)
20,000 vibrations/sec. ...(highest limit)

Animals and insects have the sensitivity over a wider range of frequencies.

2. Wave Motion : It is a kind of disturbance which propagates in a medium and is due to the repeated periodic vibrations of the particles of the medium about their mean positions, the motion being handed over from one particle to the next.

In a *longitudinal wave*, the particles of the medium vibrate forward and backwards (or to-and-fro) along the line of propagation of the wave, whereas in a *transverse wave*, they vibrate in a direction at right angle to the direction of the propagation of the wave. Due to absence of cohesion or elasticity of shape, transverse waves cannot be maintained in gases.

3. Properties of Sound Waves :

(*i*) Sound waves travel with a finite velocity.

(*ii*) The distance between the two nearest points on the wave vibrating in the same phase is called *wavelength*.

(*iii*) The number of complete vibrations executed in one second is called the *frequency* of the vibration.

(*iv*) Velocity of sound = Frequency × Wavelength

or $V = n.\lambda$

(*v*) Sound waves can be reflected (and give rise to echoes) and obey the laws of reflection as light does. Sound waves can also be refracted.

4. Velocity (V) of Sound :

(a) $V=\sqrt{\dfrac{E}{\rho}}$ (Newton's formula for solids, liquids and gases).

$V=\sqrt{\dfrac{P}{\rho}}$ (Newton's wrong formula for gases only).

$V=\sqrt{\dfrac{\gamma . P}{\rho}}$ (Laplace's corrected formula for gases only).

$=332$ metres/second at 0°C in *dry air*

where E is the elasticity of the medium, ρ is its density, P is the pressure of gas and γ is the ratio of two sp. heats of the gas.

(**b**) The velocity of sound in a gas

(*i*) is directly proportional to the square root of its absolute temp.

(*ii*) is independent of the pressure of gas ;

(*iii*) increases with the amount of moisture in the atmosphere ;

(*iv*) is inversely proportional to the square root of its density (*i.e.* in lighter gases, sound travels faster).

5. Beats : When two sources of almost the same frequency are sounded together, the resulting sound fluctuates in loudness. The number of fluctuations or beats per second is equal to the difference in frequencies of the two sources.

6. Stationary and Progressive Waves : *Stationary waves* are said to be produced when two wave-trains of same frequency travel through a medium, along the same line but in the opposite directions. In these waves, in either direction, there is no flow of energy. These waves are so called, because there is no propagation of disturbance or energy from one place to another, or the nodes and antinodes which occur in them are fixed in position. Stationary waves are a form of interference ; for example, vibrations set up in the organ pipes and stretched strings.

The waves in which all the particles of the medium execute S.H.M. with different phases along the direction of the waves are called *progressive waves*.

7. Characteristics of Musical Sounds :

(*a*) **Pitch** : By means of which we can distinguish a shrill, sharp or acute sound from a dull, flat or grave one. The pitch of a musical note depends upon its frepuency – the greater the frequency, the higher the pitch.

Pitch is a *subjective* measurement and is therefore a sensory magnitude depending upon the individual, while frequency is a *physical* measurement of the number of vibrations per second.

In ordinary whistling, the pitch is varied by changing the pressure or the size of the mouth-opening.

(*b*) **Loudness or Intensity** : It is equal to the amount of sound-energy falling per second on a unit area. It is directly proportional to the square of the amplitude of vibrations but inversely proportional to the square of the distance. A man's voice is louder but a child's or a woman's voice is shriller.

(*c*) **Quality or Timbre** : By means of which we can distinguish between two notes of the same pitch and loudness, but played on two different instruments. It depends upon the number and proportion of the *harmonics* present in a sound. *Blind* people have this sense very highly developed and can detect the very smallest differences in voices of two persons.

The quality of the human voice is modified by tongue, teeth, lips and palate.

8. Musical Scales and Intervals : The ratio of the frequencies of two notes in a musical scale is called the *interval* between the notes. When two notes are an octave apart, their frequency ratio is 2 : 1, the higher pitched note being of greater frequency.

9. The Doppler Effect : When a source of sound is moving towards or away from an observer, there is an apparent increase or decrease in the frequency (which is called the Doppler Effect) which depends upon the relative velocity of the source and observer and the true frequency of the source.

10. Transverse* Vibrations of a Stretched String : The frequency (n) of the fundamental note of a stretched string is expressed as

$$(i)\ n \propto \frac{1}{l} \qquad (ii)\ n \propto \sqrt{F} \qquad (iii)\ n \propto \sqrt{\frac{1}{m}}$$

Combining the above we have,

$$n = \frac{1}{2l}\sqrt{\frac{F}{m}} = \frac{1}{lD}\sqrt{\frac{F}{\pi.\rho}}$$

where l=resonant length ; D=diameter of wire ;

F=stretching force ; ρ=density of wire ;

m=mass per unit length of wire.

---

*In stre-ched strings, transverse and stationary waves are produced while the waves produced in the surrounding air are longitudinal and progressive, Transverse waves cannot change into longitudinal ones. Only the sound energy is communicated from the sonometer wire to the air through the wooden bridges and the box. And in air, only the longitudinal waves are possible.

11. Modes of Vibration of a String : A string which vibrates in one loop or segment has two places N, N' of no vibration at the ends (called nodes), an antinode A or place of maximum vibration in-between them, and gives out its *fundamental tone* or note (Fig. 4-1-*a*). If there are three nodes, two antinodes and two segments (Fig. 4-1-*b*), the string sounds the first overtone* or second harmonic whose frequency is twice that of the fundamental tone. And so on.

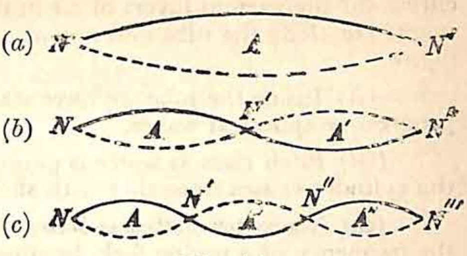

Fig. 4-1

12. Resonance : All bodies have a natural frequency of *free vibrations*. If they are made to vibrate at any other frequency, they are said to execute *forced vibrations*. If the free vibrations of one body "P" are maintained by the vibrations of another body "K" of the same frequency, then the vibrations of P are *resonant* vibrations and the bodies are said to be in RESONANCE.

"The resonance is a particular case of forced vibrations where the frequency of the driver becomes equal to the frequency of the driven". Sound heard at the resonance position is maximum because all the particles are vibrating with their maximum amplitude and natural frequency.

13. Resonance of Air-Columns : A column of air in a tube closed at one end, can be excited and can be set into resonant vibrations by a suitable source of sound. The air being in contact with water is not dry. There are longitudinal stationary waves formed inside the reasonance column and longitudinal progressive waves outside it. The resonant frequency is determined by the length of the column of air.

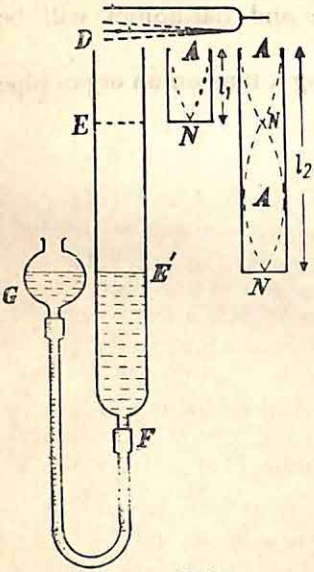

Fig. 4-2

If D be the internal diameter of the resonance tube, n the frequency of the tuning fork used and l_1 the *first resonance* length (Fig. 4-2-*b*), then the velocity of sound in air at the room temp. is

$$V=4n(l_1+0{\cdot}3\,D)$$

where $0{\cdot}3\,D$ is the *end-correction* applied to the length of air-column. If l_2 be the *second resonance* length (Fig. 4 2-*c*), then

$$V=2n\,(l_2-l_1)$$

and $$\textit{end-correction}=\frac{l_2-3l_1}{2}$$

---

*Fractional multiples of a fundamental tone are also called overtones.

Note : (*i*) These curves (Fig. 4-2-*b*, *c*) are the *displacement* curves for the various layers of air in the tube. The actual displacements are along the tube and not at right angles as shown in this figure.

(*ii*) Inside the tube we have stationary plane waves and outside progressive spherical waves.

(*iii*) Pitch rises as water is poured into a tall cylinder because the cylinder causes resonance with shorter and shorter air-columns.

(*iv*) *Sonometer method is better than Resonance method* for finding the frequency of a tuning fork, because in sonometer the resonance is sharp and a small change in length begins to produce beats. This is not so in the case of resonance air-column.

14. Organ Pipes : Every pipe will have its one end open since air is to be blown in it if the pipe has to produce sound. It is called an *open-end pipe* when its other end remains open. Evidently it will be called a *close-end pipe* if its other end is kept closed.

(*a*) **Open-end Pipe** : If its length be l and velocity of sound in air be V, then the frequency (n) of its fundamental note is

$$n=V/2.l$$

and the frequencies of fundamental note and harmonics will be in the ratio of 1 : 2 : 3 : 4 :......

(*b*) **Close-end Pipe** : Keeping other things same as above,

$$n=V/4.l$$

and the frequencies of its fundamental note and harmonics will be in the ratio of 1 : 3 : 5 : 7 :......

Snoring is the result of the air playing a tune on an organ pipe that was not meant to make music.

Objective Type Questions

CHAPTER XXVIII

WAVE MOTION AND VELOCITY OF SOUND

I. Complete the following sentences with suitable words or phrases :

(1) Sound is a kind of......motion.

(2) Wave motions are......and......

(3) ......waves constitute the sound in gases.

(4) Water waves are......waves.

(5) Sound .....travel in vacuum and requires -...for its propagation and . . of the medium executes S.H.M.

(6) When a body executes a S.H.M., its acceleration is......proportional to its displacement.

(7) $V=n\times$...... ; or $\lambda=V\times$...... ; or $n\times$......$=1$.

(8) In the case of S.H.M.

(*a*) The time period $t=2\pi\sqrt{\frac{......}{.....}}$

(*b*) The acceleration $\propto$......

(*c*) ... ..wave graph is obtained.

(9) A......produces sound.

(10) Longitudinal waves are produced in......while the transverse waves are produced in......

(11) In the...waves, the displacement of the particles takes place in the direction of the wave-motion while in the ...waves, it takes place at right angles to the direction of the wave-motion.

(12)......and......are set up in the longitudinal waves while...... and......are set up in the transverse waves.

(13) According to Newton, compressions and rarefactions occur under the......condition while the same happens under the......condition according to Laplace.

(14) $V_t=V_o+$......$\times t$ metres/sec. for velocity of sound in air.

(15) The use of several listening devices to locate hidden guns is called......

II. Select the correct answers from the clues provided against each statement below :

(1) Sound waves through gases are......waves.
[electromagnetic, longitudinal, transverse]

(2) Of the following properties of a wave, the one that is independent of the others is its......

(*a*) amplitude, (*b*) velocity, (*c*) wavelength, (*d*) frequency.

(3) Velocity of wave motion is......the velocity of the particles of the medium. [the same as, quite different from]

(4) The distance between the two nearest particles in the same phase on a wave is called...... [frequency, wavelength, displacement]

(5) The sound waves move .....in solids and liquids than in gases and moves......in air than in carbon dioxide. [faster, slower]

(6) Speed of sound is greatest in......[vacuum, air, water, solids]

(7) In a metal bar, the sound waves that propagate......

(*a*) are always longitudinal. (*b*) are always transverse.

(*c*) are always torsional.

(*d*) can be either longitudinal or transverse.

(8) Sound travels in rocks in the form of.....

(*a*) longitudinal elastic waves only.

(*b*) transverse elastic waves only.

(*c*) both longitudinal and transverse elastic waves.

(9) Transverse waves can propagate......

(*a*) both in a gas and a metal.

(*b*) in a gas but not in a metal.

(*c*) not in a gas but in a metal.

(*d*) neither in a gas nor in a metal.

(10) Velocity of sound is......the loudness of sound and the pressure. [dependent upon, independent of]

(11) Velocity of sound......with the rise of the temperature. It is......in the moist air than that in the dry air.
[decreases, increases, greater, smaller]

(12) A man at the top of a ladder hears a man on the ground ......than the man on the ground can hear him. [worse, better]

(13) Change in pressure......the velocity of sound in gases.
[changes, does not change]

(14) Velocity of sound is 4 times greater in......than in......
[oxygen, hydrogen, nitrogen]

(15) Liquids conduct sounds......readily than gases. [less, more]

(16) ......to......vib/sec. is the range of audibility for the human ear. [20 to 20,000 ; 20 to 40,000]

(17) The persistence of hearing for a normal ear is not for more than ...of a second. [1/10,1/20]

(18) Sounds of high pitch travel at......speed than sounds of low pitch. [same, higher, lower]

(19) Porous solids are .....transmitters of sound. [poor, good]

III. Find out the correct statements out of the following :

(1) Sound waves can bend round the corners.

(2) Frequency is the number of waves produced in one second.

(3) Amplitude is the maximnm displacement from the mean position.

(4) At any instant, the distance from the mean position of vibration is called the displacement.

(5) Frequency is independent of the amplitude so long as the latter is not too large.

(6) Phase is the angle made by a vibrating particle on passing through its mean position.

(7) Greater is the elasticity for the solids, more will be the velocity of sound in solids.

(8) Newton modified the Laplace formula for the velocity of sound in gases.

(9) The distance covered by one crest and one trough on a wave equals its wavelength.

(10) The time at which an explosion occurs can often be ascertained by looking at the trace of a barograph.

CHAPTER XXIX

MUSICAL SOUND

I. Complete the following sentences with suitable words or phrases :

(1) *(a)* ....*(b)* .... *(c)* ......are the characteristics of a musical note.

(2) Intensity or loudness of a musical note depends on......

(3) Pitch of a musical note depends upon the......of the source of sound.

(4) Quality of a musical note depends upon......

(5) The voice of a woman has a greater......

(6) Pleasing effect on the ear is produced by... ..while in the .... there is a sudden rise or fall in the amplitude.

(7) Musical sound is of......while a sharp sound has a......

(8) The frequency of the tuning fork......when its prong is loaded or filled with wax and......when it is filed.

(9) If the handle of a vibrating tuning fork is made to touch the top of a table, there is......in the volume of sound produced.

(10) The octave is......of the frequency of the fundamental note, while the harmonics are its......

(11) Sweeter sounds possess...... overtones.

(12) One......and one......form one beat while the......of two frequencies gives the......of beats per second.

(13) Beats can be heard when the difference in frequencies is not more than......

II. Select the correct answers from the clues provided against each statement given below :

(1) The voice of a lion is different from that of a mosquito because...

(*a*) the two animals have different sizes.
(*b*) the two voices travel with different velocities.
(*c*) the two sounds have different frequencies.
(*d*) the two sounds have different phases.

(2) Loudness of a sound does not depend upon......

(*a*) wavelength, (*b*) speed, (*c*) pitch, (*d*) amplitude.

(3) When a pleasing effect is produced on the ear by sounding two notes together, they are called to be... .while the displeasing effect leads to be...... [in discord, in concord]

(4) Pleasing effect produced by sounding two notes together is called......while......occurs when the notes are sounded one after the other. [melody, harmony]

(5) When the number of beats per second reaches 30, a......is produced. [pleasing harmony, discord]

(6) On a diatonic scale, when $Sa=24$, the other notes are... ..

(*a*) 27, 30, 32, 36, 40, 45, 48 ; (*b*) 27, 28, 29, 30, 31, 32 ;
(*c*) 27, 29, 31, 33, 34.

(7) Gramophone was discovered by......
[Coulomb, Grahm Bell, Edison]

(8) On a diatonic scale, the major tone, the minor tone and the semi-tone are......

(*a*) $\frac{9}{8}, \frac{10}{9}, \frac{16}{15}$; (*b*) $\frac{9}{5}, \frac{10}{9}, \frac{15}{16}$

(9) The holes in the disc and the top of the wind box of a siren are in the......but...directions.
[vertical, slanting, same, opposite, zigzag]

(10) Greater is the density of the medium,......is the sound.
[fainter, louder]

(11) Opening the holes of a clarinet......the pitch. [raises, lowers].

(12) Sounds of .....pitch travel at the same velocity. [same, different].

(13) The ratio between the frequencies of two musical notes is termed as...... [interval, octave, fundamental].

III. Classify the following into musical sounds and noises :

(1) Roar of a lion ; (2) Sound of thunder ;
(3) Humming of bees ; (4) Chirping of birds ;
(5) Ticks of a clock ;
(6) Report of (the firing of) a gun ;
(7) Sound produced by a tuning fork or harmonium ;
(8) Pattering of rain drops on the window or tin sheds.

CHAPTER XXX

REFLECTION OF SOUND

I. Complete the following sentences with suitable words or phrases :

(1)The vibrations are......vibrations when a body vibrates with its natural time-period, otherwise the vibrations are......vibrations when a body vibrates under the influence of an external force.

(2) ...of sound results in the formation of echoes.

(3) At a denser medium, the reflection of sound waves takes place......the change while at the rarer medium, it is .....the change of type or nature of the waves.

(4) The least distance between the listener and the echoing surface must be and for a mono-syllabic echo...

(5) A speaker is heard... ..in the room of a house than in the open air.

(6) ...is a particular case of forced vibration.

(7) In the Kundt's tube, the rod vibrates...

(8) The no. of maximum syllables a person can speak in one second is...

(9) When a railway engine approaches you, the pitch of its siren sounds ..

(10) In an open organ pipe of length l, the frequency n of its fundamental tone (when V is the velocity of sound)=...

(11) In a closed organ pipe of length l, the frequency n of its fundamental note (when V is velocity of sound)=...

(12) In closed organ pipes, only...harmonics are heard.

(13) In open organ pipes, only ..harmonics are heard.

II. Find out the correct statements out of the following :

(1) The stethoscope intensifies sound because it substitutes for the drum of the ear a larger membrane.

(2) One hears better at the top of a mountain because the air is rarer.

(3) It is not possible to have an echo if the sound wave passes from a denser to a rarer medium.

(4) The time of reverberation of a hall is independent of the positions of the source of sound and of the observer.

(5) Women are better absorber of sound than men on account of the nature of their dress.

(6) Kundt's tube can be used to find the velocity of sound in solids, liquids and gases.

(7) Melde's experiment is used for the study of the formation of stationary waves.

(8) When a body begins to vibrate under the influence of another body, provided their frequencies or time periods are equal, resonance is said to take place.

(9) Resonance tube is used to find the velocity of sound accurately in air.

(10) End-correction is a correction applied because the reflection of waves does not take place exactly at the end of the resonance tube but slightly higher.

(11) Beats are heard when there is a slight difference of frequencies of two sounds.

III. Match the quantities given in two columns :

Column A	*Column B*
(1) Wave-length	(*a*) $2n, 3n, 4n, \ldots$
(2) Increase in the velocity of sound in air for 1°C rise of temp.	(*b*) $N \pm n$
	(*c*) 0·61 metre/sec.
(3) Overtones in an open-end pipe.	(*d*) $\frac{\text{velocity}}{\text{frequency}}$
(4) Overtones in a closed end pipe.	
(5) Frequency of a wire vibrating transversely.	(*e*) $n.m$
(6) Determination of pitch by the method of beats.	(*f*) $\frac{1}{2l}\sqrt{\frac{F}{m}}$
(7) Determination of pitch by the method of siren.	(*g*) $3n, 5n, 7n, \ldots$
(8) Velocity of sound in air.	(*h*) $4n.(l+0{\cdot}3D)$.

CHAPTER XXXI

TRANSVERSE VIBRATION OF STRINGS

I. Complete the following statements with suitable words or phrases :

(1) The vibrations of a string are...

(2) The note which a string, vibrating as a whole, produces is called its......

(3) The points where strain is......and displacement is......are called nodes.

(4) The points where change of pressure is......and displacement is...are called antinodes.

(5) Between two nodes, there must be at least one...

(6) The fixed ends of the vibrating rod are......while the free ends are...

(7) With the increase in the length and diameter of the stretched string, its frequency...

(8) The frequency......with the increase in the stretching force of a wire.

(9) The frequency of a sonometer wire will......if the wire is made hollow.*

(10) The outcomes of the Melde's experiment are, (*a*)......(*b*)......

(11) In stationary waves, there is no forward......of the disturbance.

(12) In stationary waves, all particles execute periodic motion of different but......amplitude.

(13) In stationary waves, all particles pass through the...position and...displacement at the same time.

(14) In stationary waves, twice in one complete time-piriod, all particles are at rest...

(15) The distance between one node and the nearest antinode is ...while between the two consecutive nodes is...

(16) The sonometer is an instrument which is based on the laws of......

(17) A violinist tunes his violin by adjusting the......of its strings.

(18) The string of a guitar producing high notes are......than those producing low tones.

(19) Sound is recorded by a...

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*Mass per unit length decreases when the wire is made hollow.

II. Select the correct statements out of the following :

(1) Overtones are produced when a stretched wire is plucked from its centre.

(2) Stationary waves are those waves which do not move onwards.

(3) Stationary waves are formed when two equal and similar waves travelling in opposite directions superimpose upon each other.

(4) The frequency of the overtones are odd multiples of the fundamental tone in a closed-end pipe and are any mutliples in an open-end pipe.

(5) Decibel is the unit of the loudness of sound.

(6) Finger-nails should not be used for plucking the wire of a sonometer as this introduces overtones.

(7) The note emitted by a vibrating wire depends upon the amplitude of the wave produced.

(8) A pipe of length L and closed at both ends will resonate for wave lengths$=2L/N$ where $N=1, 2, 3,$...any positive integer.

III. Name the devices or instruments used for following purposes :

(1) To catch reflected sounds under water ;

(2) To produce a pure note ;

(3) To find the velocity of sound in air accurately :

(4) To find the velocity of sound in solids ;

(5) To demonstrate the interference of sound ;

(6) To study the laws of transverse vibration of strings ;

(7) To study the formation of stationary waves ;

(8) To record sound ;

(9) To reproduce sound.

Short-Answer Questions

1. *What is a Simple Harmonic Motion ?*

Ans. A S.H.M. is a to-and-fro motion of a particle which repeats itself after regular intervals (called its time-period). Its acceleration is proportional to its displacement and is directed towards its mean position. It is graphically represented by a sine-curve.

$$\text{Time-period of S.H.M.} = \frac{2\pi}{\sqrt{\text{Acceleration per unit displacement}}}$$

2. *How does sound travel ?*

Ans. Sound travels in the form of longitudinal wave-motion in solids, liquids and air or gaseous media, and also in the form of transverse wave-motion in the case of a solid medium. The medium must be material, continuous and elastic. The speed varies very considerably with the medium through which sound propagates.

3. *If a gun were fired from the moon, would you hear its sound ?*

Ans. *No,* since there is vacuum between the earth and the moon. Sound does not travel through vacuum ; for its propagation, it needs a continuous material medium. The so-called imaginary medium of ether, which is supposed to be all-pervading (even in vacuum) and which was coined by scientists to explain the wave-theory of light, is not a material medium.

4. *Why can you hear a noise in the next room even though the doors are tightly shut ?*

Ans. For its propagation, sound needs an elastic, material and continuous medium. The air in the two rooms and the intervening walls as well as the doors—all these provide elastic, material and continuous media for the propagation of sound or noise from one room to the other even when the doors are tightly shut.

5. *How can you make a building sound-proof ?*

Ans. For this we get a hint from the fact that for its propagation, sound requires an elastic, material and continuous medium. Everything used in the construction of a building constitutes an elastic and material medium. Therefore, for a sound-proof building, we should somehow make the medium discontinuous. It is generally done by constructing *hollow walls and extractiug the intervening air.* Sound cannot travel through vacuum.

[**Note** : This arrangement makes the *building heat-proof* also.]

6. *State a few essential differences between the modes of transmission of sound and light waves.*

Ans. (*i*) In air, the sound waves are longitudinal but light waves are transverse.

(*ii*) A continuous material medium is a must for the propagation of sound but light waves can pass through vacuum.

(*iii*) Velocity of sound in air at 0°C is about 330 m./sec. and sound travels faster in solids and liquids than in air while velocity of light in air is 3×10^8 m./sec. and light travels slower in solids and liquids than in air.

7. *How do we hear a sound ? Is it really sound which travels ?*

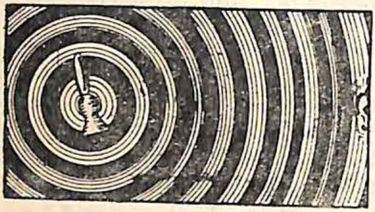
Fig. 4-3

Ans. Whenever we hear a sound, there must be a material, elastic and continuous medium between the source of sound and our ears. Generally, it is air ; and in air only longitudinal waves can be produced. A body produces sound only when it vibrates to-and-fro between two extreme positions. On account of these vibrations, compressed and rarefied layers of air are alternately formed (Fig. 4-3). These compressions and rarefactions are handed over from one layer of air to the next and thus reach the receiving ear. Consequently, the ear-drum starts vibrating sometimes with greater amplitude and sometimes with less amplitude corresponding to whether the compressed layer is incident on it or it is the rarefied layer of air – and produces the original sound of the source inside the ear.

Thus it is *really not sound which travels* from one place to another. The sound is changed into alternately compressed and rarefied layers (of air) which set the ear-drum into vibration - resulting in the reproduction of sound, inside the air.

8. *If you are hearing a sound, its source must be vibrating.* Is the opposite also true ?*

Ans. The opposite is *not true*, *i.e.* it is not essential that we must hear a sound from each and every vibrating body. For a sound to be audible, two things are essential : (*i*) the incident sound-waves should possess enough energy to compel the ear-drum to vibrate and (*ii*) the ear-drum must be in a position to vibrate with the frequency of the incident sound-waves. The first factor fixes the lower limit of the incident frequency which is 20 vibrations per second and the second factor fixes the upper limit of the incident frequency which is

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* An **electric buzzer** is an electric bell from which the hammer and the gong have been removed and its armature is made very light so as to vibrate very rapidly, producing a high pitched note or 'buzz'.

20000 vibrations per second. Thus the audible range for a normal ear is from 20 vib./sec. to 20000 vib./sec.

9. *Which one do you consider to be a better instrument—the ear or the eye ?*

Ans. The eye sees only one octave (*i.e.* wavelengths between 4000 – 8000 *A.U.*) whereas the ear hears several octaves (frequencies between 20 – 20000). Hence the ear is a better instrument.

10. *If an observer places his ear at the end of a long steel pipe, he can hear two distinct sounds when a workman hammers on the other end of the pipe. Explain.*

Ans It is due to the fact that velocity of sound is different for different media, *i.e.* it is greater in solids than in air or gaseous medium.

When a workman hammers on the pipe, the sound thus produced will travel through the air and the solid (steel pipe) media respectively. Velocity of sound in steel is 16 times greater than that in air and hence due to this time gap, the observer will hear two distinct sounds.

11. *Why is it possible to detect the approach of a distant train by placing the ear upon the rails of the track ?*

Ans. We know sound travels faster in solids than in air. The rails, being solid metal and continuous, conduct the sound of the engine-wheels much more quickly and with less loss of energy than the surrounding air does. Hence the above experience is justified.

[**Note** : (*i*) Since the teeth act as a solid medium, that is why *a deaf person can hear the tick-tick sound of his watch held against his teeth.*

(*ii*) For the same reason, the sound of the paddles of a steamer is audible through water even when the ship is at a great distance from the shore.

(*iii*) Similarly, if one's ears are placed under the surface of water in a domestic bath, it is easily possible to hear a conversation taking place in the room below.]

12. *While watching a cricket match, why do we see the ball strike a moment before we hear the sound of the bat hitting the ball ?*

Ans. It is due to the fact that light has a far greater speed than sound. We see the bat striking the ball in the flash of a second ; but since sound travels at a much less speed than light, the sound of striking must be heard after some time. Hence the above abservation.

[**Note** : Similarly we can answer the following questions :

(*i*) *Why is there a time-lag between our observing a flash of lightning and hearing the thunder ?* Measuring this time-lag and multiplying it by the velocity of sound in air at that temp., we get the distance of clouds producing lightning.

(ii) When we set our watch by the sound of a distant siren, it will be too slow.]

13. *Why do the steps of soldiers, when marching in a long file, appear to be irregular ?*

Ans. Sound travels with a constant speed in air (this speed being 332 metres/sec. at $0°C + 0{\cdot}61$ metre/sec. increase for each $0°C$ rise of temp.) and hence to cover different distances it must take different intervals of time. Since the soldiers in a long file are at different distances from the observer, therefore the sounds of their steps reach the observer's ears in varying periods of time and not simultaneously. This results in a continued step and not in a sharp step.

[**Note** : For the same reason, the persons in the rear of a long procession marching to music are unable to keep in step with those in front.]

14. *When sound travels through gases, is it under isothermal condition or adiabatic condition ? And why ?*

Ans. On account of absence of cohesion, a gas cannot maintain transverse waves ; hence through a gas sound travels in the form of longitudinal waves which consist of alternately compressed and rarefied layers of the gaseous medium. Thus

(*i*) the compressed layers gain heat while the rarefied layers lose heat ;

(*ii*) the heat produced during compression does not easily pass, through a bad conducting gas, over to the regions of rarefaction to compensate for the cooling caused there ; and

(*iii*) these changes take place so rapidly that there is no time (on account of a great velocity of sound) for the heat to pass from one region to another.

Hence different regions of a gas during the propagation of sound are at different temps. and the gaseous medium is in *adiabatic* state and not in isothermal state.

[**Note** : These were Laplace's main arguments for correcting Newton's formula for the velocity of sound in gases.]

15. *Sound is heard much more clearly and over a greater distance by night than by day. Why ?*

Ans. It is because night-air is more uniformly dense and less liable to currents caused by the heat of the sun. Thus there is less irregular (*i*) reflection as well as (*ii*) refraction* of sound waves at night. The first factor is responsible for clear sound and the two together for its distance.

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*The higher velocity of sound waves in warm air causes sound waves to be refracted down at night and up in the day time.

Also there is a lot of noise during the day, due to the walking and talking of men, animals, factories, etc.

16. *Do you think that the sound of an explosion of a bomb travels at the same speed as that of a mosquito's voice ?*

Ans. *Yes*. All sounds whether loud or soft, in harmony or discord, music or noise, travel at the same speed through any given medium. The speed with which sound travels does not depend upon its loudness, pitch or quality. This was experimentally verified by many scientists by determining the speed of sound produced by a volcanic eruption.

17. *Why is it possible to hear more easily and clearly a person speaking in a room than in the open air ?*

Ans. It is because the sound waves, on reaching the walls of the room, are reflected back without a loss of energy and mix with the direct waves of the speaker's voice—thus augmenting it. On the other hand, sound waves are not reflected from the open air and they progressively move further away. Thus the audience hears only the direct sound of the speaker.

[**Note** : Even in a room, the loudness of a sound decreases when windows are opened since open windows serve the purpose of the best sound absorbant or the worst reflector.]

18. *Why is the sound in a hall, packed with audience, fainter than the sound in the same hall when it is empty ?*

Ans. In an empty hall, the sound is reflected not only from the walls but also from the polished surface of the furniture and no absorption takes place on these surfaces. The reflected sound mixes with the direct sound—as a result a louder sound is produced.

On the other hand, if the hall is packed with audience, not only the area of reflection of sound decreases but also the clothes of the people absorb sound incident on them. Therefore, in this case, the resultant sound becomes fainter.

[**Note** : To direct some reflected sound towards the ear, we generally *hold our palm near our ear while trying to listen to a whisper*.]

19. *Why do deaf people sometimes use an ear-trumpet ?*

Ans. Ear-trumpet is wide on one side and narrow at the other. It restrains the spread of the approaching sound waves and concentrates them in a much narrow space by reflection on its walls. This results in increasing the ultimate strength of sound waves when they enter the ear.

20. *How does a megaphone (loud-speaker) increase the travelling power of sound ?*

Ans. A megaphone consists of a funnel-shaped horn. The sound, produced at its narrow end, is not allowed to spread out in all directions. This sound rather suffers successive reflections from the inner surface of the horn and is thus concentrated into one narrow beam in a single direction. Evidently, the ensuing sound becomes louder and can be heard at greater distance.

[**Note** : For the same reason, we bring our hands around the mouth in a cup-form while shouting to somebody at a distance.]

21. *How is the working of a physician's stethoscope due to reflection of sound waves ?*

Ans. When the stethoscope is kept in contact with the left side of the chest, its membrane starts vibrating in-and-out due to the heart-beatings. These vibrations cause enough change in the pressure of enclosed air—giving rise to longitudinal waves which suffer successive reflections from the side of the tube. The sound waves are thus concentrated and when they fall on the ear-drums, one can quite distinctly hear the magnified and louder beatings of the heart.

22. *What are whispering galleries ? Why are they so called ?*

Ans. A whispering gallery is one in which a whisper is audible anywhere or everywhere. Such galleries are made in circular buildings and their working is based upon successive reflection of sound taking place from its opposite walls. Since there is no loss of energy, therefore the sound of a whisper can be heard at a great distance inside such a gallery. For receiving a clear whisper, the ear must be kept close to the wall of the gallery—as if the walls are whispering. Hence this name.

[**Note** : *Sounds cannot be heard very far over freshly fallen snow* which is a bad reflector ; on the other hand, *at night over smooth water sounds can be heard at a great distance.*]

23. *What causes the rumbling of sound of thunder ?*

Ans. This is due to *reverberation* or *multiple echoes.* Sound of thunder will get reflected successively from the two colliding clouds and will mix up with the original thunder. Since these clouds are close to each other, the successive echoes cannot be heard separately. This mixing or overlapping produces a long roll of thunder, also known as rumbling of sound.

[**Note** : If a thunder is reflected one after the other from the surrounding rings of clouds, it produces an impression as if the source of sound is rolling over the clouds. This is called *rolling thunder.*]

24. *Why do the stages of large auditoriums have curved backs ?*

Ans. This is done so that when a speaker stands at or near the focus of the curved surface, his voice is rendered parallel after reflection from the concave or parabolic surface. In this way his voice can be heard clearly upto a long distance.

25. *Why is the ceiling of a Prompt Box on a stage made concave ?*

Ans. The Prompt Box is kept in one front corner, well above the stage. Its concave ceiling serves a dual purpose—(*i*) to prevent what the prompter is saying from reaching the andience, and (*ii*) to reflect his voice towards the actors on the stage.

26. *How many echoes be of use to ships at sea during a heavy fog to locate their position ?*

Ans. To locate the position of a ship at sea (during a heavy fog), we require *at least two echoes* from two known places (say A and B) situated at the sea-shore. Suppose these intervals are 10 and 14 seconds respectively for two echoes. Then the distance between the ship and the place A is the distance covered by the sound in air in $10/2=5$ seconds while that between the ship and the place B is equal to the distance covered by the sound in air in $14/2=7$ seconds. If the velocity of sound in air at that time be, say, 360 metres/sec., then on a chart on any known scale draw two arcs of radii 360×5 metres and 360×7 metres with A and B as centres respectively. Then the point of intersection of these arcs will give the location of the ship.

27. *Can one sound when added to another sound produce a low resultant sound ? If yes, then how ?*

Ans. *Yes*, it is possible. When two sounds of slightly different frequencies are produced together, these set up their respective compressions and rarefactions. At some points of the medium when the compression of one falls on the rarefaction of the other, that is, they are in the *opposite phases*, the resultant sound equals the difference of two sounds and so a low or faint sound is heard.

[**Note :** One the other hand, at some points of the medium the compressions of the two sounds will coincide and thus the two sounds being in the same phase will produce a louder sound equal to the sum of their intensities. This thing occurs when *beats* are produced and these fluctuations of sound can be easily counted if their number is less than 10 per second (=difference of the frequencies of two original sounds).]

28. *What is the difference between noise and musical sound ?*

Ans. Musical sound is the result of regular vibrations which follow a complicated law. On the other hand, noise is a mixture of sounds collected together at random and having no tone, tune or timbre therein. The margin between noise and musical sound is not clearly drawn, and that which is music to some may be noise to others. Broadly speaking, a noise has no definite loudness, pitch or timbre, and thus any attempt to determine its quality would be meaningless.

29. *Why are bells usually made of "bell-metal" ?*

Ans. It is because some substances are sonorous and others are not. Bell-metal, which is composed of four parts of copper and one part of tin, is a harder and more elastic alloy than any one metal and is thus *sonorous*. Other metals, such as lead, are too soft to be sonorous.

30. *Why does a cracked bell sound harsh ?*

Ans. It is because the split causes double vibrations and the two different sets of sound-waves clash. This clash results in the production of alternately louder and lower sounds. Since these vibrations impeding each other will last for a short interval and their amplitudes have increased on account of the crack, they produce a jarring effect on the ear.

31. "*An empty vessel makes much noise*". *How can you justify this proverb* ?

Ans. We know that the intensity of sound is proportional to the square of the amplitude of the vibrating body. When an empty vessel is struck, it begins to vibrate with a greater amplitude since air filling it is highly compressible. Moreover, the air filling the empty vessel is also set into vibrations producing sound due to compressions and rarefactions which also possess large amplitude. Thus the resultant (or total) sound will be much louder.

On the other hand, when the vessel is filled with, say, water and then struck, the water molecules will also be set into vibration but their amplitude will be much smaller than that of air molecules. Moreover, the water will not allow the vessel also to enjoy its full swing as water is not compressible. Thus the resultant sound will be lower.

Hence an empty vessel produces more sound than a filled one.

32. *Two sound notes can be distinguished by their pitch, quality and loudness. Indicate with brief explanation which one is the distinguishing feature in each of the following cases* :

(*i*) *Notes emitted by two different tuning forks.*

(*ii*) *Notes emitted by two wires of different materials, having the same fundamental frequency.*

(*iii*) *A note and its echo.*

Ans. (i) : The sound of a tuning fork, being pure, will have no overtones. Their loudness will be the same when struck with the same force. The distinguishing factor is *pitch* because the notes emitten by two different forks will have different frequencies and hence different pitch.

(ii) : When the fundamental frequency of two wires is same, that means pitch is same. Also their intensities will also be the same as the wires are sounded simultaneously (as their amplitudes will be equal). Thus the distinguishing factor is *quality* (or *timbre*) because the wires are of different materials and therefore the overtones produced will be different.

(iii) : In this case, *intensity* (or *loudness*) is the distinguishing factor. Echo is the reflection of sound ; it will have the same pitch and quality as the original sound. But due to distance, the intensity of the echo will be reduced much more than that of the original sound.

33. *Why are the slight sounds, heard in a diving-bell, of painful intensity to the ears ?*

Ans. Intensity of sound depends upon the density of the intervening medium—less is the density, less is the intensitv and *vice versa.* Because the air in the diving-bell is made very dense by the pressure of the surrounding water, the intensity of sound in it increases many fold (just as the rarity of air diminishes the intensity of sound). Hence a painful or jarring effect is produced on the ear of a diver in a diving bell.

[**Note** : At the same pressure, a louder sound will be heard in oxygen than in hydrogen but the sound will travel faster in hydrogen than in oxygen.]

34. *How do you recognize your friend simply by his voice, without seeing him ?*

Ans. Sounds differ from one another in their intensity, pitch and quality. All these three factors help us to recognize our friend by his voice only. But it is the *quality* of his sound which helps us the most to distinguish his sound from another sound of the same pitch and same loudness.

In its turn, the quality of a sound depends upon the presence, number and intensity of harmonics accompanying the fundamental tone. Different sounds are accompanied by different harmonics. We are familiar with the harmonics of our friend's voice and hence can recognize him simply by hearing his voice.

[**Note** : The first five harmonics give richness and fullness to the notes, while the higher harmonics give brilliancy.]

35. *What do you mean by a tone and a note ?*

Ans. A sound that is produced by a pure sine vibration is called a tone. A sound that is produced by a periodic complex vibration is called a note. A note is a sound of definite frequency and its wave-curve is simple harmonic. A tuning fork gives more or less a pure note.

36. *What is the difference between a harmonic **and** an overtone ?*

Ans. When a body is sounded, in addition to its lowest or fundamental note, it produces other notes of higher frequencies which are exact multiples of its fundamental. These are termed harmonics.

A note of higher frequency which is not a simple multiple of the fundamental is called overtone.

37. *Why does the transposition of a piece of music from one musical key to another of a piano often completely alter the character of the work ?*

Ans. It is caused by the fact that no piano is tuned to a strictly mathematical ratio between each note ; if this were done, a number of notes far in excess of those at present in use, would be required. We are content with approximately accurate notes. Our present tempered or temperate scale considers the sharp of a note as equal to the flat of the succeeding note—thus reducing all the notes in an octave to twelve. The temperate scale has become generally accepted and our musicians no longer know that it is an inaccurate scale.

The use of this remodelled but inaccurate scale means that some of the finer delicacies of music have been destroyed. Thus the chords of certain keys are not in a perfect tune and this imperfection gives rise to beats as well as to a different musical form.

38. *How does the use of the temperate scale affect stringed instruments, flutes and trumpets ?*

Ans. Stringed instruments and the human voice have their notes perfectly free and untrammelled by a keyboard, and can therefore have the pitch of their notes shifted at will by the artist. And a flute or trumpet player can just as easily play in the true scale as in the temperate one.

39. *Is it always true that "an echo does not lie" [that is, a reflected sound has the same pitch as the original direct sound] ?*

Ans. *No*, it is not always true. The pitch of a reflected sound does not equal that of the original sound in cases when the source of sound or the obstacle from which the sound is reflected, or the observer is moving (Doppler Effect).

40. *Why does the pitch of a locomotive siren steadily rise as the train approaches and fall as it is receding ?*

Ans. It is because of Doppler Effect*, according to which the frequency of a note is increased as each sound-wave has added to its normal speed of travel that of the engine (which is about one-tenth the speed of sound). Similarly, after the engine has passed, one-tenth of the speed of the sound-waves is deducted from the original note – thus lowering its pitch.

This can be mathematically ascertained by using the relation

$$V = n.\lambda$$

or $V \propto n$ when λ is constant.

[**Note** : The pitch of the whistle on a fast moving train sounds normal to the observers off at the sides.]

41. *It is required to tune a string to unison with a tuning fork and both are accordingly made to sound at the same time. Beats occur. After a small weight has been attached to one prong of the tuning fork, the frequency of the beats is reduced. What must be done to the string (tighten or slacken it) so that it should be tuned to unison with the tuning fork ?*

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*Since the universe as a whole is expanding, a distant star is going away from the observer on earth and so the visible light from it shifts generally towards the red-end of the spectrum.

Ans. Frequency of beats equals the difference between the frequencies of the string's vibrations and those of the tuning fork. Attaching a weight to the tuning fork will decrease the frequency of its vibrations, while tightening the string will increase its vibration-frequency. Therefore, if the attaching of a weight reduces the frequency of the beats, this means that the tuning fork's frequency has approached the string's frequency which must be less than that of the tuning fork. Hence to tune the string to resonance with the tuning fork, the string should be *tightened.*

[**Note** : A sitar-tuner uses beats in tuning his piano because its strings are in tune when no beats are heard]

42. *How can you use a simple form of siren to produce (i) a steady note, (ii) wailing note ?*

Ans. When the siren disc is rotated with a uniform speed and the jet is held against the same ring of holes, then the siren produces a steady note. If on the other hand, the disc is rotated with a variable speed or the jet is moved from one ring of holes to the other, then the siren produces a note of varying frequency.

[**Note** : In a siren the holes are made equidistant in order to produce a sound of regular frequency.]

43. *What is the purpose of the bridge of a violin ?*

Ans. The bridge communicates the vibrations of the strings to the body of the instrument, which, being hollow, resonates* in sympathy with the strings. Moreover, the area of the vibrating surface increases. Both these factors augment and improve the volume and tune of the sound.

[**Note** : Here volume means loudness of sound which can further be increased by increasing the amplitude of vibration of the violin-string.]

44. *Why is a tuning fork so called ?*

Ans. A tuning fork is so called because it is in the shape of a *fork* and when struck against a (soft) surface, it *tunes, i.e.* it produces a musical sound.

45. *Why is a tuning fork made with two prongs ?*

Ans. The prongs of a tuning fork working normally move in opposite phases, *i.e.* they are always moving in opposite directions. Therefore, C.G. of the tuning fork remains stationary and hence no external force is required to cause these oscillations. Thus the tuning fork can make its oscillations without being rigidly fixed.

46. *Would a tuning fork be of any use for its normal purpose if one of the prongs were sawn off ?*

Ans. If one of the prongs be cut off and the remaining prong makes oscillations of the same sort as before, then C.G. will no longer remain stationary. Consequently an external force must act in order that these oscillations should occur, *i.e.* the tuning fork must be rigidly fixed (*e.g.* the handle should be clamped in a vice). There is then an outside force acting, on the part of the clamp, which brings C.G. into motion. But if the handle be simply held in the hand, the fork will not be sufficiently rigidly fixed and oscillations cannot occur.

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*That is why the sonometer box is made hollow.

47. *What is the use of the stem of a tuning fork ?*

Ans. (*i*) The stem provides a handle for holding the tuning fork. As the vibrations in the stem are parallel to its length, they do not die out when the stem is held in the hand.

(*ii*) The energy produced by the vibration of the tuning fork is transmitted through the stem to the sounding board.

48. *Why does a tuning fork give a pure note only ?*

Ans. Because its first overtone is about six octaves above the fundamental and is very weak. Also any other overtones present are heavily damped and hence quickly die out.

49. *What is the effect of temp. on the note of a tuning fork ?*

Ans. Due to the increase in temp., the prongs of a tuning fork increase in length and also the elasticity of the steel (*i.e.* its material) is diminished. Therefore the frequency of vibration of the tuning fork will be lowered.

50. *What factors govern the pitch of a tuning fork ?*

Ans. The pitch of a tuning fork is :

(1) inversely proportional to the *square* of the *length* of the prongs ;

(2) directly proportional to the *square root* of the *elasticity* of the material of the fork ;

(3) directly proportional to the *thickness* of the prong ;

(4) inversely proportional to the *square root* of the *density* of the material of the fork ;

(5) *independent* of the *width* of the fork ;

(6) directly proportional to the velocity of transverse waves in the material of the fork.

[**Note** : The alphabet written on a tuning fork stands for the frequency of its note on the diatonic scale.]

51. *If we cut a notch 1 mm. deep and 1 mm. wide near the top of each arm of a tuning fork, what will happen to its frequency ?*

Ans. The frequency of a tuning fork varies inversely as the square of length of its prongs and inversely as the square root of the mass of its prongs. When the mass decreases, the frequency increases and *vice versa*.

Thus when we cut a notch near the top of each prong of the tuning fork, we are decreasing its mass and hence its frequency *increases*.

[**Note :** When the prongs are *filled* or loaded with a small quantity of wax, the frequency of the tuning fork decreases. But when the prongs are *filed*, its frequency increases. Remember the *difference* between the two cases of **filld** and **fieled**.]

52. *What are stationary waves ?*

Ans. When two progressive waves of exactly the same wavelength move in opposite directions (two such waves are generally one incident wave and the other its reflected wave when the reflection has been suffered on a denser medium), the resultant disturbance is called a stationary wave which remains confined to the space where it is produced and does not proceed in either direction. Every particle of such a wave has a fixed amplitude of vibration.

53. *State a few important properties of stationary waves.*

Ans. (*i*) There is no forward motion of the wave.

(*ii*) All particles execute periodic motion of different but fixed amplitude and same time period.

(*iii*) All particles pass through mean position as well as through maximum displacement at the same time.

(*iv*) All the particles are twice at rest at the same time in one complete time-period.

(*v*) Distance between any two consecutive nodes (where strain is maximum but displacement is zero) or antinodes (where strain is minimum but displacement is maximum) $= \lambda/2$.

54. *Where will you hear a louder sound – at the node or at the antinode of displacement of a stationary wave ?*

Ans. An observer hears a sound when variable pressure acts on his ear-drum. At the antinode, the amplitude of vibration has its maximum value while the change in pressure is practically zero. But at the node, the amplitude is zero while there is maximum change in pressure. Therefore, we will hear a louder sound at the *node* of a stationary wave.

55. *Why are marching soldiers ordered to disperse before approaching a bridge on a river ?*

Ans. If a column of soldiers is allowed to march in steps on a bridge, it itself (if it is a suspension bridge) or its span will be forced to vibrate also. If by chance the time period of the marching column equals that of the vibrating span of the bridge, resonance will occur between the two. Consequently with each step, the amplitude of vibration of the span will go on increasing and ultimately the bridge (or its span) will collapse. It is to avoid this possibility that the soldiers are ordered to break steps and not to march as a group when crossing a bridge.

[**Note** : Due to sympathetic vibrations or resonance, windows sometimes rattle when the low notes of an organ pipe are sounded. In such a manner, windows might be broken.]

56. *On gradually increasing the speed of a bus, its whole structure starts vibrating very strongly at a certain speed. How will you explain it ?*

Ans. Whenever a bus is in motion, forced vibrations are produced in its structure by the oscillating piston of the engine. The speed of the bus can be increased by increasing the frequency of the piston. When at a particular speed, the frequency of the bus-structure equals that of the piston, *resonance* occurs between the two. As a result of resonant vibrations, the whole structure of the bus starts vibrating very strongly. To avoid this, the driver then slightly increases or decreases the speed of the bus.

57. *Why does the resonant frequency of the air-column rise when water is poured in a tall cylinder ?*

Ans Let us consider the case of first resonance. If l cm. be the first resonance length of the air column of the cylinder, V cm./sec. the velocity of sound in air at that time, n the resonant frequency and D cm. the internal diameter of the cylinder so that the end-correction is 0·3 D cm., then

$$V=4n(l+0{\cdot}3D)$$

Since V and D are constant, therefore n will be inversely proportional to l. That is, when water is poured in the cylinder, the length l of the air-column decreases and hence the resonant frequency n has to increase.

58. *How will it affect the resonance position if some oil is used instead of water in Resonance Apparatus ?*

Ans. It *will not affect* the resonance position at all if water is replaced by any other liquid—provided that liquid is not lighter than air and so far no such liquid is available. Moreover, we are concerned with the length of the air-column and not with that of the liquid-column.

[**Note** : The resonance position will be changed if the diameter of the tube of Resonance Apparatus is changed because then the end-correction to be applied to the length of air-column will change.]

59. *How will it affect the resonance position if the resonance experiment is performed on a mountain ?*

Ans. It *will not affect* the resonance position at all. Although the pressure on the mountains is less than that on the plains but pressure has no effect on the velocity of sound in gases.

60. *How will it affect the resonance position if a heavy gas like CO_2 is filled in the resonance apparatus at atmospheric pressure ?*

Ans. Since the density of CO_2 is greater than that of ordinary air, therefore the velocity of sound will decrease. With the decrease in velocity, the wavelength also decreases and consequently the length of resonance column will also decrease.

61. *What is end-correction and why is it applied to a resonance air-column ?*

Ans. In the resonance apparatus, the waves are reflected first from the surface of water upwards and reach the open end of the tube. Since here the medium is comparatively rarer, hence these waves cannot suffer reflection just from the top of the tube ; they go a little above and are then reflected downwards in the tube. Consequently, the *end* of the tube has to be considered slightly higher than its actual top. The correction proposed for this is called *end-correction.*

[**Note** : It equals $0{\cdot}3D$ where D is the *internal diameter* of the tube. For a given tube, its value will thus remain constant whether we are dealing with the first or the second* or the third resonance length.]

62. *Why do we not take a very narrow resonance tube to make the end-correction negligible ?*

Ans. In that case, the intensity of sound due to less volume of vibrating air will be reduced and the judgement of the resonance position will not be accurate.

63. *Can we take resonance tube of square cross-section ?*

Ans. **(i)** : *No*, if we are using the first resonance method since we would not know the end-correction to be applied.

(ii) : *Yes*, if we are using the second resonance method since the end-correction will be eliminated.

64. *Which organ pipe—close-end or open-end – gives a better musical sound and why ?*

Ans. When air is blown at higher and higher pressure in an organ pipe, the air-column vibrates in more and more segments – as a result the pipe produces sounds of higher and higher frequency.

In the case of a close-end pipe, the frequencies of various overtones along with the fundamental tone are in the ratio of 1 : 3 : 5 : ... That is, all the overtones are not present, alternate overtones are missing and hence the quality of sound produced by this pipe cannot be good.

On the other hand, these frequencies are in the ratio of 1 : 2 : 3 : 4 : ......for an open-end pipe. Since here all possible overtones are present, the quality of sound produced by an *open-end pipe* must be better than that produced by a close-end pipe.

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*Resonance at the second and third positions is feebler than that at the first since their frequencies are respectively three and five times the fundamental and therefore the vibrations become feebler. Moreover, in the second and third resonances, the sound has to travel longer distances.

65. *A tuning fork which is octave to an organ pipe can make it "speak" if the pipe is open-end but not if it is close-end pipe. How can it be explained ?*

Ans. Octave means of twice frequency, *i.e.* if the frequency of the fundamental tone of the organ pipe be n, then the frequency of the tuning fork will be $2.n$.

In the case of a close-end pipe, possible frequencies of various tones are in the ratio of 1 : 3 : 5 :......Since here, digit 2 is missing, this pipe can never produce a sound of frequency $2.n$ and hence the given tuning fork cannot resonate it.

On the other hand, in the case of an open-end pipe these frequencies are in the ratio of 1 : 2 : 3 : 4 : ...... Since here, digit 2 is present, this pipe can be made to resonate (or to speak) with the given tuning fork.

66. *For what wavelength would a pipe, of length L cm., that is closed at both ends, resonate ?*

Ans. When the pipe is closed at both ends, the ends will represent nodes (represented by N) and there must be at least one antinode (represented by A) between two nodes when this pipe vibrates in minimum number of parts (Fig. 4-4-a). Since the distance between a node and an adjacent antinode equals one-quarter of a wavelength, therefore the wavelength (say λ_1) of the fundamental tone is given by :

$$2(\lambda_1/4)=L \text{ or } \lambda_1=2L$$

In the next mode of vibration (Fig. 4-4-b), we have 3 nodes and 2 antinodes. If λ_2 be the wavelength of the first overtone, then

$$4(\lambda_2/4)=L \text{ or } \lambda_2=L$$

Similarly for the next overtone (Fig. 4-4-c), we have

$$6(\lambda_3/4)=L \text{ or } \lambda_3=2L/3$$

Thus in general, the different wavelengths for which this pipe will resonate are

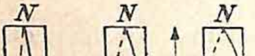

Fig. 4-4

$$\frac{2L}{1}, \frac{2L}{2}, \frac{2L}{3}, \ldots\ldots \frac{2L}{n}$$

when $n=1, 2, 3,\ldots$etc., any positive integer.

67. *What is the function of sharp knife-edges fixed over the wooden bridges of a sonometer ?*

Ans. (1) The knife-edges *limit* the length of the vibrating wire.

(2) They facilitate accurate measurement of *length* of the wire.

(3) They determine the position of *nodes**.

(4) They provide for *reflection* of sound-waves so that the wire between them may have stationary vibrations.

68. *Can we use a rubber string in place of a metallic wire in a sonometer ?*

Ans. *No.* Because

(*i*) the vibrations will die out very soon in a rubber string ;

(*ii*) the length of the string will increase under the action of an ordinary load ; and

(*iii*) the sound produced may not be audible under ordinary tension.

69. *Why are strings of different thickness used on a stringed instrument ?*

Ans. The frequency of a note produced by a vibrating stretched string under a constant tension is inversely proportional to the diameter (or thickness) of the string. Thus by using strings of different diameters, notes of different frequencies can be obtained by vibrating the same lengths of different strings.

70. *A wire, supported at its upper end and kept in tension by a freely hanging weight attached at its lower end, emits a faint sound when plucked. But the same wire under the same tension, when stretched over a board, emits a much louder sound when plucked. Why is it so ?*

Ans. It is due to the increased area of vibrating surface. In the first case, only the wire vibrates. But in the second case, the vibrations of the wire are transmitted to the board through the knife-edges. Thus the board's surface also starts vibrating. Simultaneously the air enclosed inside the sonometer box also starts resounding. Hence the observed difference in the volume of two sounds.

71. *Is it important that a gramophone record should be played at the frequency marked on it ? What would happen if it is rotated (a) much slower, (b) much faster ?*

Ans. *Yes* : it is very important that a gramophone record must be played at the frequency/speed marked on it so that our ears listen to a normal sound. For a normal sound, each alphabet takes 0·2 second. If the record is rotated much slower, the duration of sound of each alphabet or word will be lengthened and it will appear as if the sound is coming out of a throat which is being throttled by somebody. On the other hand, if the record is rotated much faster, the duration of sound of each alphabet or word will be shortened and we will not be able to hear different words clearly and separately, as a result we will hear a sort of shrieking sound.

72. *Why is it that a gramophone reproduces music clearly with a new sharp needle but not with an old blunt needle ?*

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*The rider/riders should be placed on antinode/antinodes to detect the resonance of the sonometer wire due to a tuning fork most efficiently.

Ans. It is because there are very fine grooves on the record and these grooves consist of very fine holes of varying depths. An old blunt needle cannot enter these holes and that too upto a proper depth—as a result the old needle cannot vibrate properly and more freely than the new and sharp needle. Hence the observed difference in the use of two needles.

73. *Why does a short phonograph-needle make the sound louder* ?

Ans. A phonograph-needle is really a lever. The shorter arm causes the other end of the needle to vibrate through a greater amplitude, resulting in a louder sound.

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1. A *dictaphone* is a machine reproducing in typed form what is spoken into it.
2. A *hydrophone* is an instrument to detect sound by water.
3. A *saxophone* is a kind of brass musical instrument.
4. A *xylophone* is a musical instrument like harmonica in which glass slips are replaced by graduated hard bars of wood.
5. *SONAR* is a short form of **So**und **N**avigation **A**nd **R**anging.

Part V—Magnetism

Concise Magnestism

1. Chief Properties of Magnets : (*i*) Magnets can transfer some of their magnetic properties by contact with nickel, iron and cobalt.

(*ii*) When suspended freely, a bar magnet will set itself in north and south direction. It is its *directive property*.

(*iii*) A magnet will attract nickel, iron and cobalt. If a bar magnet is dipped into iron filings, the centres of regions in which they cling most strongly are the **poles.** They are situated near but not at the ends of a magnet. It is its *attractive property*.

(*iv*) The pole of a magnet which points towards north is called north-seeking or *North pole.* The other pole which points towards south is called south-seeking or *South pole.*

(*v*) It is impossible to produce an isolated pole.

(*vi*) By heating or rough-handling, a magnet may be made to lose its properties or also by the influence of another magnet arranged with their poles in opposition.

2. Methods of Making a Magnet : (*a*) By earth's induction.

(*b*) By single-touch method. (*c*) By double-touch method.

(*d*) By divided-touch method.

(*e*) By placing the specimen in a solenoid and passing a fairly heavy current around it. It is called *electrical method.*

3. Magnetic Materials : The cheif magnetic materials are iron and steel Lode-stone is a naturally magnetised iron ore consisting mostly of Fe_3O_4, an oxide of iron. Its original source was from Magnesia, a province of Lydia in Asia Minor, the name of magnet being derived from this place. Nickel and cobalt are also natural magnetic materials and the alloys **Alnico** and **Ticonol** which contain Al, Ni, Cu and Cobalt in addition to iron are strongly magnetic.

Magnetism, according to molecular theory, is due to the molecules of the substance being arranged in some special pattern or formation.

4. Magnetic Fields : A magnetic field is a region or space around a magnet, over which the influence of a magnet can be detected. The earth has a magnetic field which is roughly that which would be caused by an immense bar magnet in its interior.

5. **Laws of Magnetic Poles** : (*i*) Like poles repel and unlike poles attract each other, along the line joining the two poles.

(*ii*) The force (F) of attraction or repulsion between two magnetic poles (of strength say m_1 and m_2) is directly proportional to the product of their pole strengths and inversely proportional to the square of the distance (say r) between them.

6. (*a*) **Unit Magnetic Pole** : Unit magnetic pole is that pole which when placed in air 1 cm. away from another equal and similar pole repels it with a force of one dyne. The unit of magnetic pole-strength is the *Weber*.

(*b*) **Pole-strength** is numerically equal to the force which the given pole exerts on a unit north pole placed 1 cm. away from it in air.

(*c*) **Intensity of Magnetisation** of an element of a magnet is the magnetic moment per unit volume. It is also defined as the pole-strength per unit area of the pole-face.

7. **Magnetic Lines of Force** : In a magnetic field, the lines of force at a point indicate the *strength and direction* of the field at that point.

If a free unit north pole were placed at a point in a magnetic field, then the line of force at that point gives the direction in which it would travel.

8. **Magnetic Induction** : If a piece of iron or steel is brought near *but not touching*, a bar magnet, it is found to become magnetised itself. The end nearer the north pole becomes a south pole. The specimen is said to be an *induced magnet*. Its magnetism disappears when the inducing bar magnet is removed.

9. **Magnetic Field-strength** : It is measured by the force which it exerts on a unit north pole. A field is said to have strength of one dyne per unit pole or one *oersted* when it exerts a force of one dyne on a north pole of strength one weber.

In a field of strength H oersted, a pole of strength "m" webers is subjected to a force of "$m.H$" dynes.

A *uniform magnetic field* has the same strength or intensity at all the points situated in it and can be represented by *parallel lines of force.*

10. **Magnetic Moment** : Magnetic moment of a magnet is numerically equal to moment of that couple which will keep this magnet at right angles to the direction of a magnetic field of unit intensity. Mathematically, the moment of a magnet is equal to the product of its pole strength (m) and magnetic length ($2l$) :

$$M = m \times 2l \text{ weber-cm.}$$

Magnetic moment is a *vector* quantity.

11. **Deflection Magnetometer** : This instrument has been designed to make the magnetic measurements by virtue of deflection produced

in a magnetic needle, suitably placed in a non-magnetic cup-box, obeying tangent law *i.e.*, $F=H.\tan\theta$ when the two fields (F and H) are at right angles at the centre of the needle.

Deflection Magnetometer can be set in either of the two positions : (*i*) Tan-A position or A-position or First Position of Gauss [in which $F=2rM/(r^2-l^2)^2 \simeq 2M/r^3$] and (*ii*) Tan-$B$ position or B-position or Second Position of Gauss [in which $F=M/(r^2+l^2)^{3/2} \simeq M/r^3$]. Morever it utilises either Deflection Method or Null Method.

It is used for comparison of (*i*) moments of magnets, (*ii*) fields due to magnets, and (*iii*) earth's horizontal fields at two places.

12. Vibration Magnetometer : It consists of a box in which a small bar magnet is freely suspended by an unspun silk thread. The magnet can execute torsional vibrations about the thread as an axis in a horizontal plane and its time period is given by

$$t=2\pi\sqrt{I/M.H}$$

where I is its moment of inertia and depends upon its mass and dimensions but not on its pole-strength.

Its uses are similar to those of the Deflection Magnetometer.

13. Neutral Point : It is a point where resultant magnetic intensity is zero. It is a point in a magnetic field where the field (F) due to a magnet is generally equal and opposite to the horizontal component (H) of earth's magnetic field and therefore at the neutral point the total field is zero *i.e.*, $F=H$ and no lines of force can pass through this point.

Neutral points commonly occur when bar magnets are used in conjunction with earth's field.

If a magnetic needle is freely suspended at a neutral point, the needle will become vertical under the effect of vertical component of earth's magnetic field since the effect of horizontal component (H) is absent or nullified at a neutral point.

14. Earth's Field ; (*i*) *Cause* : As the earth revolves from West to East, there is a constant stream of electrons in the higher atmosphere from east to west—the atmosphere lagging behind the earth's revolution. This probably produces a magnetic field along North and South, like the earth's field.

(*ii*) Under the influence of the earth's magnetic field, a freely suspended compass needle sets itself along magnetic north and south.

(*iii*) In order to completely specify the earth's intensity at any point on the surface of earth or the space around it, we need to know the following three things, called *earth's magnetic elements* at a place :

(a) Declination : It is the angle between the geographical meridian and the magnetic meridian at that place. It is represented by θ in Fig. (5-1).

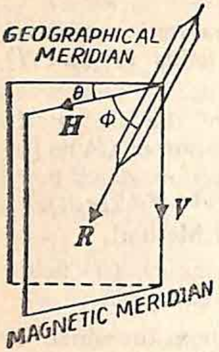


Fig. 5-1

(**b**) A uniform bar magnet, suspended by a torsionless thread at its mid-point, sets itself in north-south and with its north pole dipping downwards. The angle (ϕ) between the axis of this magnet and the horizontal is called **dip** or **angle of inclination** (Fig. 5-1).

[**Note** : An iron rod should be placed parallel to the dip needle in order that the rod may acquire the maximum induced magnetism from the earth's field.]

(**c**) There is no doubt that earth behaves as if it is a strong magnet. As such, a definite intensity R of the earth's field can be associated at every point on it. In horizontal direction, the effect of R, the total intensity of earth's field, is denoted by its **horizontal component** $H=R.\cos\phi$, where ϕ is the angle of dip.

Also $\quad R=\sqrt{V^2+H^2} \quad$ and $\quad V/H=\tan\phi$

where V represents the vertical component of R and is equal to $R.\sin\phi$.

Objective Type Questions

CHAPTER XXXII

MAGNETS AND THEIR PROPERTIES

I. Complete the following statements with suitable words or phrases :

(1) ......is a natural magnet and a magnetic needle is...... magnet.

(2) The word "magnet" has originated from...

(3) Attractive and......are the two important properties of a magnet.

(4) Unlike poles...while like poles...each other.

(5) Repulsion is a...of magnetism.

(6) Induction...attraction.

(7) A magnet attracts a piece of soft iron due to...

(8) In induction, the nearer end gets...polarity and the farther end gets...polarity.

(9) A st. line passing through the poles of a magnet is called its...and a vertical plane passing through the magnetic axis of a freely suspended magnet at rest is called...

(10) Electro-magnets are...and of...

(11) Steel is used for making...magnets.

(12) When a magnet is cut, its each piece will be a...in itself.

(13) The...property of a magnet can be explained on the basis of...property.

II. Select suitable word or words to complete the following statements from the clues provided against each :

(1) Poles of a magnet are of...strengths. [equal, different]

(2) At the centre of a bar magnet, magnetism is... [maximum, minimum, zero]

(3) Poles of a magnet...be separated. [can, cannot]

(4) A substance which is strongly attracted by a magnet is called a ...substance, one which is feebly attracted by a magnet is called a...substance, and the one which is repelled by a magnet is called a...substance. [para-, ferro-, or dia-magnetic]

(5) Magnetic lines of force...longitudinally and ...laterally. [contract, expand]

(6) A substance which is......by a magnet is called a non-magnetic substance. [neutral, dead, neither attracted nor repelled]

(7) For magnetism, retentivity of...is greatest and susceptibility of...is greatest. [soft iron, steel, brass]

(8) Two rods of soft iron hang vertically side by side from a support. On bringing one end of a magnet near the rods from below, they... [separate, cling together]

(9) Two rods of soft iron hang vertically side by side from a support. On bringing one end of a magnet near the rods from the side, they... [separate, cling together]

III. Select the correct statements out of the following :

(1) Magnetic length=Geometric length of a magnet.

(2) A freely suspended magnet points towards East and West.

(3) Two magnetic lines of force never cut each other.

(4) Lines of force run from South pole to North pole.

(5) Spin-motion of the electrons in the atom causes magnetism.

(6) Magnetism is destroyed by beating or heating a magnet.

(7) A magnet may be demagnetised by the use of an alternating current.

(8) The core of an electromagnet is made of soft iron.

IV. Classify the followings into magnetic and non-magnetic substances :

Steel ; Silver ; Glass ; Wood ; Nickel ; Iron ; Copper ; Manganese ; Aluminium ; Bismuth ; Cobalt ; Sulphur ; Sugar ; Wax; Graphite.

CHAPTER XXXIII

MAGNETIC FIELD

I. Complete the following statements with suitable words or phrases :

(1) The force of attraction or repulsion between two magnetic poles is......proportional to the product of their pole strengths and... proportional to the square of the distance between them.

(2) Magnetic intensity at a point is the force experienced by a ...placed at that point.

(3) The unit of magnetic induction is...and that of the strength of the magnetic field is...

(4) The magnetic pole is said to be of unit strength which when placed in air at a distance of...from...pole, repels it with a force of...

(5) The magnetic intensity at any point on the end-on position or on the axial line of a magnet acts along . direction.

(6) The magnetic intensity at any point on the broadside-on position or on the equatorial line of a magnet acts along...direction.

(7) The space surrounding a magnet is called...

II. Select the completions from the clues provided against each of the following statements :

(1) Inverse Square Law of magnetic force was stated by...

[Ampere, Ewing, Weber, Coulomb]

(2) ...is a unit of intensity of magnetic field.

[Volt, Oersted, Dyne, Gauss]

(3) ...is the path traced by a unit north pole. The tangent at any point on it gives the...of the resultant intensity at that point.

[direction, line of force, path]

(4) Magnetic moment of a magnet......if it is halved breathwise.

[increases, decreases]

(5) Magnetic moment of a magnet......if holes are drilled in it.

[decreases, increases, remains same]

(6) A bar magnet of length L has a magnetic moment M. It is then bent into a semi-circular arc. The new magnetic moment is...

[M, $M.L$, M/L, $2M/\pi$]

(7) Magnetic moment is a...quantity and magnetic field is a... quantity.

[scalar, vector]

(8) A magnetic field is......when its intensity is same at every point.

[same, uniform, non-uniform]

(9) Pole strength of a magnet is expressed in...

[oersted, volt, gauss, weber]

(10) When the distance between two magnetic poles is reduced to half, the magnetic force between them is increased to...times.

[2, 4, 8]

(11) If a short bar magnet be moved away from a point on its axial line to double the previous distance, its intensity will reduce to ...of its previous value.

[$\frac{1}{2}$, $\frac{1}{4}$th, $\frac{1}{8}$th]

(12) If a short bar magnet be brought to half its distance from a point on its equatorial line, its intensity will become...of its previous value.

[$\frac{1}{2}$, $\frac{1}{4}$th, $\frac{1}{8}$th, twice, 4 times, 8 times]

(13) If a magnet is placed along the mag. meridian with its N-pole towards north, the neutral points are obtained on its...line.

[axial, equatorial]

(14) If a magnet is placed along the mag. meridian with its N-pole towards south, the neutral points are obtained on its...line.

[axial, equatorial]

(15) Iron...a magnet. [attracts, does not attract]

III. Select the correct statements out of the following :

(1) A lodestone was also called a *leading* stone because it could be used by sailors to lead their ships on the sea.

(2) Sometimes a magnetised bar exhibits three poles.

(3) When one pole of a strong magnet is suddenly brought near a similar pole of another weak magnet, attraction takes place.

(4) A non-uniform magnetic field can be represented by parallel lines of force.

(5) For a longer magnet, the magnetic moment is less.

(6) Pole-strength of a magnet is directly proportional to its cross-sectional area.

CHAPTER XXXIV

MAGNETOMETRY

I. Complete the following statements with suitable words or phrases :

(1) When the Deflection Magnetometer is set for Tan-A position, its arms are towards ...... and the magnet is placed ...... to the arms.

(2) In the Tan-B position of the Deflection Magnetometer, its arms are towards ......and the magnet is placed ...... to the arms.

(3) In a Deflection Magnetometer, ... pointer is attached to the magnetic needle.

(4) A/an......fibre is used in the Vibration Magnetometer for suspension.

(5) To eliminate the measurement of moment of inertia, we employ ... .. method for the comparison of magnetic moments with the help of a Vibration Magnetometer.

II. Select the appropriate completions from the clues provided against each of the following statements :

(1) Tangent Law is applicable only when......

(*a*) there are two magnetic fields.

(*b*) there are two like parallel magnetic fields.

(*c*) a magnetometer is used.

(*d*) horizontal component of earths's magnetic field is present.

(*e*) two uniform and mutually perpendicular magnetic fields are used.

(2) While using a Deflection Magnetometer, ... method gives more accurate results. [Null, Deflection]

(3) While using a Deflection Magnetometer, ... setting gives more accurate results. [Tan-*A*, Tan-*B*]

(4) In a Deflection Magnetometer, the given magnet always points towards ...... [north-south, east-west]

(5) In Tan-*A* setting of a Deflection Magnetometer, ... is kept parallel to its arms. [magnetic needle, aluminium pointer]

(6) In Tan-*B* setting of a Deflection Magnetometer, ... is kept parallel to its arms. [mag. needle, aluminium pointer]

(7) A magnet is divided up into four equal parts so that the length as well as the breadth of each part is half of the original magnet. Then the pole-strength of each is ...... of the original magnet. [$\frac{1}{2}$, $\frac{1}{4}$th, $\frac{1}{8}$th]

(8) Same as Q. 7 above. Then the magnetic moment of each part is ... of the original magnet. [$\frac{1}{2}$, $\frac{1}{4}$th, $\frac{1}{8}$th]

(9) Same as Q. 7 above. Then the moment of inertia of each part is ..... of the original magnet. [$\frac{1}{4}$th, $\frac{1}{8}$th, $\frac{1}{16}$th]

(10) Same as Q. 7 above. Then the time-period of each part is ...... of the original magnet at the same place. [2 times, $\frac{1}{2}$, 4 times, $\frac{1}{4}$th]

(11) While comparing magnetic moments with the help of a Vibration Magnetometer, sum and difference method is applied when the use of third magnet is ...... [allowed, not allowed]

(12) In a Vibration Magnetometer, sum and difference method is possible only when (M_1-M_2) is ... .. [large, small, zero]

(13) In a Vibration Magnetometer, the sum and difference method will fail when (M_1-M_2) is...... [infinite, zero]

(14) Oscillations of a compass needle become...... as we approach the North pole of the earth. [slower, faster]

III. Matching Test :

Column A	*Column B*
(1) Tangent Law—the principle of a Deflection Magnetometer.	(*a*) $\left(\frac{r_1}{r_2}\right)^3$
(2) Comparison of magnetic moments by a Deflection Magnetometer.	(*b*) $\left(\frac{L^2}{12}+\frac{r^2}{4}\right)\times$ mass
(3) Comparison of magnetic moments by a Deflection Magnetometer by Deflection Method.	(*c*) $\left(\frac{L^2+B^2}{12}\right)\times$ mass
(4) Comparison of magnetic moments by a Deflection Magnetometer by Null Method.	(*d*) $\left(\frac{r_1}{r_2}\right)^3\times\frac{\tan\theta_1}{\tan\theta_2}$

(5) Moment of inertia of a rectangular bar magnet.	(*e*) $F=H. \tan \theta$
(6) Moment of inertia of a cylindrical bar magnet.	(*f*) $M.H. \sin \theta$
(7) Comparison of magnetic moments by a Vibration Magnetometer.	(*g*) 1
(8) Moment of couple acting on a deflected magnet.	(*h*) $\frac{\tan \theta_1}{\tan \theta_2}$
(9) Product of time-period and frequency.	(*j*) $\frac{n_1^2+n_2^2}{n_1^2-n_2^2}$

IV. Tick Mark Test (*i.e.* Choose the correct statements) :

(1) Intensity of magnetic field at a point is proportional to the square of the distance.

(2) Tangent Law is used in the Deflection Magnetometer.

(3) A Vibration Magnetometer can be used for comparing the pole-strengths of two magnets.

(4) The magnetic needle in a Deflection Magnetometer box always indicates North-South direction.

(5) In a Vibration Magnetometer, $n \propto \sqrt{H}$ or $\sqrt{M}$.

(6) The absolute value of H can be calculated by using both the Deflection and Vibration Magnetometers.

CHAPTER XXXV

TERRESTRIAL MAGNETISM

I. Completion Test :

(1) The *N*-pole of earth's magnet is towards the geographical...

(2) The knowledge of earth's......is necessary to study the intensity of the earth's magnetic field.

(3) Magnetic elements of earth are (*a*) ...... (*b*) ...... (*c*) ......

(4) Declination is the angle between......at a place.

(5) Dip is the angle between......and its......at a place.

(6) The......pole of a freely suspended magnet in the northern hemisphere will dip downwards.

(7) A mariner's compass indicates the......directions.

(8) Line joining the places having no value of dip is called ...... line.

(9) Lines joining the places having the same value of dip, declination and H are called ...... , ... and ...... lines respectively.

(10) Imaginary line joining the places having no value (or zero angle) of declination is called ...... line.

II. Choose the correct completions from the clues provided against each statement :

(1) For finding the correct value of dip at a place with the help of a dip circle, ... readings should be taken. [4, 8, 16, 32, 40]

(2) A map on which the values of dip and declination at various places of the world are shown, is called a ......
[world map, magnetic map, laboratory map]

(3) ...... is said to occur when a large change in the values of earth's magnetic elements takes place.
[Magnetic storm, Magnetic laxity]

(4) In the polar region, the angle of dip is .....
[0°, 45°, 90°, 180°]

(5) In a dip circle, its magnetic needle oscillates in a...... plane.
[vertical, horizontal]

(6) At the magnetic equator, a dip needle will stay ......
[vertical, horizontal]

(7) Earth's magnetic field always has a horizontal component, except at ......
[magnetic equator, geographical poles, magnetic poles]

(8) Which of the following statements indicates that the earth behaves like a giant magnet ?

(*a*) The earth spins on its axis.

(*b*) The earth revolves round the sun.

(*c*) Electrically charged particles emitted by the sun are able to reach the earth.

(*d*) Auroras appear both at the north and south poles of the earth.

III. Choose the correct statements :

(1) $H=R. \sin \phi$ for earth's magnetic elements.

(2) At the magnetic poles, the dip needle will stand vertical.

(3) Isogonic line is a line passing through the places having the same dip.

(4) Earth behaves as a magnet though it is not made of iron.

(5) Due to the movement of the ship on the sea, a Mariner's compass does not remain horizonal.

(6) A weaker magnet will make more swings in the earth's field during same interval.

(7) Magnetic maps are used by sailors to find out the right (correct) direction of a place after adding the angle of declination to the original geographical meridian.

Short-Answer Questions

1. *Why are artificial magnets preferred to natural magnets ?*

Ans. A natural magnet or a lodestone has three drawbacks :

(*i*) It is very weak in strength while in practice we need strong magnets.

(*ii*) It is irregular in shape while in practice we need magnets of definite but various shapes.

(*iii*) It is brittle and so it cannot be chiselled into any particular shape. It will not last long also.

These drawbacks have been removed in artificial or man-made magnets. Hence their preference over natural ones.

2. *While making a permanent magnet, what essential properties will you look for selecting a material ?*

Ans. (*i*) High retentivity ; (*ii*) High coercivity ;

(*iii*) Large hysteresis loss :

(*iv*) Immunity to loss of magnetism by alternating fields, mechanical ill-treatment or temp. changes.

3. *Is there such a thing as unmagnetisable steel ?*

Ans. *Yes.* The effect of alloying magnetic steel with manganese is very curious. If the latter element is present to the extent of exactly 15%, the alloy will be almost unmagnetisable (its magnetisability or margnetic moment being less than 1/7000 of that of good magnetic steel).

4. *What determines the lifting power of a magnet ?*

Ans. The lifting power of a magnet depends upon its *strength* and *shape.* The lifting power of a horse-shoe magnet is 3 to 4 times greater than that of a bar magnet of the same strength.

5. *Why is it that the lifting power of a magnet will gradually increase when the load is also slowly increased ?*

Ans. This is a curious and inexplicable character of a magnet by reason of which it will bear a load far in excess of its original lifting capacity. When the increased load is removed, the power of the magnet again falls to its original value.

6. *'A magnet attracts only a magnet'—how will you justify this statement ?*

Ans. When a magnet is brought near a magnetic substance, say an iron piece, *induction* takes place. The inducing pole of the magnet induces opposite pole on the nearer end of the iron piece and similar pole on the other end. Since unlike poles attract each other, attraction takes place between the magnet and the iron piece. Thus the iron piece first becomes a magnet by induction and then only it is attracted by the magnet. In other words, a magnet attracts only a magnet since *induction precedes attraction.*

7. *When one pole of a strong magnet is suddenly brought near a similar pole of another weak magnet, attraction takes place instead of repulsion. Why ?*

Ans. If the strong magnet is *slowly* brought near the weak magnet, repulsion will take place between their approaching similar poles since the requisite time to exhibit their (mutual) repulsion is available to the poles. But when the strong magnet is suddenly brought near the similar pole of the weak magnet, induction takes place. Since the strength of the induced pole depends upon the strength of the inducing pole as well as upon the distance between them, the induced pole not only nullifies the polarity of the weak magnet but also changes this polarity. Evidently, the attraction will now take place between the opposite poles.

8. *How can you show that a given bar is a magnet, without the aid of any other equipment ?*

Ans. Break the given bar into two pieces. If attraction or repulsion takes place on bringing one end of one piece near any one end of the other piece, then the given bar is a magnet. We know that each piece of a magnet when broken into parts will be a complete magnet in itself having two poles.

9. *How will you distinguish between two similar-looking pieces of iron, out of which one is a magnet, when no additional equipment is available ?*

Ans. (i) : We know that maximum quantity of iron filings sticks to a magnet at its two ends (where its poles are situated) and none at all at its centre (known as its neutral region). Now take one (say *A*) of the given iron pieces in your hand and let the other piece (say *B*) lie on the table. Touch the middle part of *B* with one end of *A*. If there is no attraction, then the piece *A* (which is in your hand) is an unmagnetised bar while *B* is a magnet. On the other hand if there is attraction, then *A* is a magnet and *B* is an unmagnetised bar.

[**Note** : (*i*) We cannot suspend the given pieces since the thread, an additional equipment or apparatus, is not available.

(*ii*) We can not distinguish between them on the basis of attraction because attraction (as well as repulsion) is mutual, *i.e.* a magnet attracts iron and an iron piece attracts a magnet.]

Ans. (ii) : Use single touch method and several times rub *A* over *B*. Now test whether there is repulsion between their ends. If you experience repulsion, then *A* is the magnet which has magnetised *B* also. If there is no repulsion, then *B* is the magnet.

[**Note** : This method will fail if one of the given pieces is of soft iron.]

10. *It is suspected that a magnetised steel rod has a north pole at each end. How would you test this ?*

Ans. When suspended, an unmagnetised rod will stay in any direction and a magnetised rod will stay in north-south direction. But a magnetised rod having consequent pole at the centre (and two similar poles at its ends) will stay in *east-west* direction on account of two equal and opposite couples acting on it.

11. *What happens when a test-tube loosely filled with iron filings is laid horizontally on a table and stroked with one pole of a magnet several times in the same direction ?*

Ans. On testing, this test tube is found behaving like a magnet. These iron filings can be supposed to be representing Weber's molecular magnets. When a magnet is rubbed along the tube several times in the same direction, the iron filings on the top arrange themselves along parallel paths and exhibit polarity at the end of the tube. [If we now apply a jerk to the test tube, it is found to have lost magnetism since the iron filings have again brought themselves to a haphazard arrangement.]

12. *Can the strength of a magnet be increased upto any value ? Explain.*

Ans. When a piece of nickel, iron or cobalt is magnetised by contact method or by electrical method, its strength goes on increasing as the number of rubbings or the strength of the current goes on increasing since more and more groupings of molecular magnets break up and thus an increasing number of molecular magnets arrange themselves along parallel paths. But this happens upto a certain *limit*. This limit is reached when all the molecular magnets are arranged along parallel paths. [This stage is known as *magnetic saturation*.]

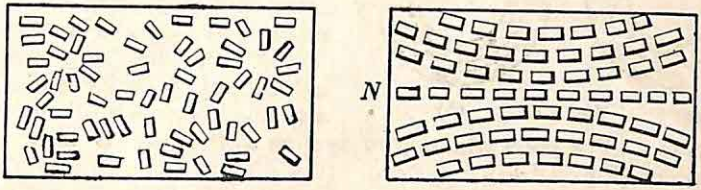
13. *How can you prove that the two poles of a magnet are of equal strength ?*

Ans. (**i**) : According to Weber's theory of molecular magnetism, in a magnet these molecular magnets are arranged along parallel paths in such a way that their north poles point in one direction and south poles in the other (or opposite) direction. Since the number of these poles are equal, both the poles of a magnet must have the same strength.

Ans. (**ii**) : Place a magnet on a piece of cork floating on water. The magnet, along with the cork, will simply rotate and stay in the north-south direction even when displaced from the original direction several times. There will be no translatory motion—confirming that both the poles have equal and opposite strengths so that a couple acts on the deflected magnet.

14. *Why is magnetism concentrated at the ends of a magnet?*

Ans. In an unmagnetised bar, the molecular magnets are pointing at random in all directions (Fig. 5-2-*a*) forming closed chains so that there are no free ends of a molecule. But in a magnet these molecules are in alignment* (Fig. 5-2-*b*) so that their north poles point in one direction and south poles in the other direction. In the middle of the magnet, north and south poles of molecular magnets are still in juxtaposition and neutralise each other's effects, but at the ends there are rows of un-neutralised poles. That is why magnetism is concentrated at the ends of the magnet.



(*a*) (*b*)

Fig. 5-2

15. *Why are the poles situated a bit inside a magnet and not just at its ends?*

Ans. The fact that a bar magnet's poles occupy a considerable area and are not confined to the extreme ends of the bar is explained by the mutual repulsion of the poles at the ends, which causes the molecules to spread out into the fan-shape (Fig. 5-2-*b*). On drawing tangents to these molecules, we shall get a point, a bit inside each end, from which these tangents will diverge. These points are the two poles of the magnet.

16. *How can you magnetise a flat steel ring so that it may exhibit polarity at opposite ends of a diameter?*

Ans. Heat the given steel ring to a high temp. and then hold it between the poles of a powerful horse-shoe magnet in such a away that the diameter of the ring lies along the line joining the two poles of the magnet (Fig. 5-3).

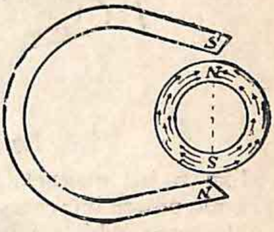


Fig. 5-3

The molecules af a substance are always vibrating slightly (except at the temp. of absolute zero). But when it is heated, its molecules vibrate more violently. Thus the molecular magnets of the steel ring come into an unstable equilibrium. These molecules are brought into alignment by the field of the horse-shoe magent and this alignment will become

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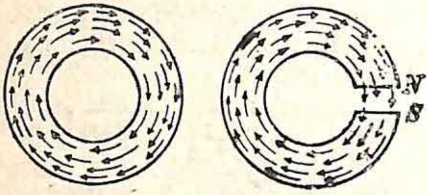
*This alignment is supported by many facts. Some facts have been dealt with in these questions. Other facts are (*i*) slight increase in the length of a bar magnet on magnetisation, (*ii*) production of clicking sound on suddenly magnetising or demagnetising a bar, (*iii*) production of heat by rapidly magnetising and demagnetising a substance.

permanent when the steel ring cools down to room temp. Thus the ring acquires two poles at opposite ends of its diameter as shown in Fig. (5-3).

17. *How can you magnetise a flat steel ring so that it may exhibit no polarity ?*

Ans. Rub one pole of a powerful magnet along the circumference of the ring and gradually go on increasing the radius of this circumference. This will break the closed chains and will bring molecular magnets in alignment or along parallel paths (Fig. 5-4-*a*). But the ring will not exhibit any polarity since there are no free poles of molecular magnets. [The poles will appear as soon as the ring is now cut at any place (Fig. 5-4-*b*)].



(*a*) Fig. 5-4 (*b*)

18. *How would you prepare a magnet without using nickel, iron or cobalt ?*

Ans. This can be done with the help of electric current. When current runs through a copper solenoid, the solenoid behaves like a bar magnet (Fig. 5-5). With the increase of current, its magnetic power increases. So the magnetism is due to the movement of electrons which produces current. If the current is flowing clockwise, that end will be S-pole and for anticlockwise* flow of current, it will be N-pole. This can be verified by observing repulsion between one pole of a magnet and the current-carrying coil attached

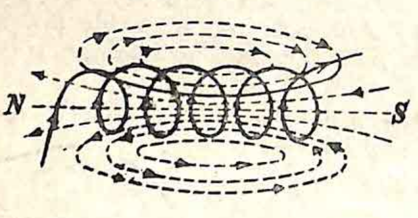


Fig. 5-5

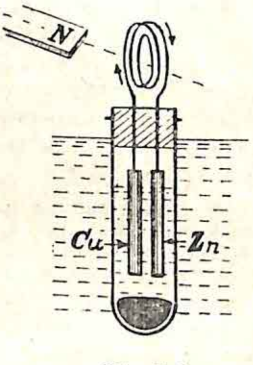


Fig. 5-6

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*Anticlockwise moment is +ve and N-pole is also +ve. On the other hand, clockwise moment is negative and S-pole is also taken as a negative pole.

A unit north pole, when placed outside the solenoid or in the vicinity of a bar magnet, is attracted by the south pole and repelled by the north pole of the solenoid or magnet. Hence, like an induction line of force, *a north pole will move inside the solenoid, away from the south pole towards the north pole.*

to the terminals of a floating voltaic cell (Fig. 5-6—this arrangement is known as De la Rive's Floating Battery).

19. *What is the cause of the earth's magnetism ?*

Ans. There are two modern views :

(*i*) Due to intense heat and enormous pressure inside the earth, large deposits of iron have become magnetised inside it. Hence the earth behaves as a magnet.

(*ii*) Magnetism is also attributed due to the movement of elections. There is a stream of electrons flowing in the regions of the earth's crust and in the air above it. As the earth revolves from West to East, there is a constant stream of electrons in the higher atmosphere from East to West : the atmosphere lagging behind the earth's revolution. This probably produces a magnetic field —North and South (in a direction perpendicular to the plane of the current.)

20. *Are the magnetic forces too available in the outer space as they are inside the earth ?*

Aes. *Yes*. Just like earth, many stars have magnetism. Every year, a number of dark spots appear on the sun. By examining the light sent out by the atoms near the sun spots, scientists find that these atoms have been affected by magnetic fields from the outer space.

21. *How can a steel bar be magnetised by hammering ?*

Ans. (**i**) : Before hitting the bar gently and constantly with a (wooden) hammer, hold it in a position parallel to the earth's magnet. [The exact direction of the earth's magnet at a place can be known with the help of a Dip Circle.]

(**ii**) : Before hitting the bar with a hammer, place it symmetrically on as well as along the length of a powerful bar magnet.

In each method, the molecules in the bar get additional energy and are shocked physically from a deranged order into a definite arrangement (of North and South) on account of earth's* magnetic field or that of the magnet underneath. The bar thus becomes magnetised.

22 *What is the effect of placing two equal magnets, end-to-end, with the opposite poles in contact ?*

Ans. If we place two equal magnets, end-to-end, with their opposite poles in contact, the combination behaves as a single magnet of *double the length* but of *same pole-strength* since the area of cross-section (and therefore the number of un-neutralised molecular magnets at each end) remains same. This follows from Weber's theory of molecular magnetism. Becauce the magnetic moment is equal to the product of the length and the pole strength of the magnet, therefore the magnetic moment of the combination will also become twice.

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*On account of induction of earth's magnetic field, iron pillars embedded with their one end in the earth, become magnetised. For the same reason, a carpenter's tools left untouched for several months are found magnetised.

23. *What is the effect of placing two equal magnets, one upon the other, with their like poles in contact ?*

Ans. In this combination, the *length remains same* but the *pole-strength will become twice* since the cross-sectional area becomes twice. This follows from Weber's theory of molecular magnetism. Here the magnetic moment of the combination will also become twice.

24. *Why does a single bar magnet get demagnetised by itself ?*

Ans. According to Weber's theory, a magnet consists of a number of molecular magnets with their north poles directed towards one end and south poles towards the other. The free or unneutralised poles N, S at the ends *induce* poles at the ends of molecular magnets, like $n-s$, opposite to those which are already present—thus trying to demagnetise the molecular magnets (Fig. 5-7). This results in the demagnetisation of the magnet by itself after some time. [This effect is greater for shorter magnets.]

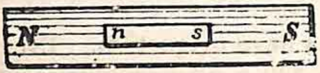

Fig 5-7

25. *A single bar magnet gets demagnetised by itself. How can this be prevented ?*

Ans. This demagnetisation can partly be prevented by keeping magnets in pairs with their *unlike poles together* so that the poles of one magnet induce the same poles on those of the other magnet. Yet there will be some loss of magnetism from the ends of the combination. To avoid this, we keep *keepers* (soft iron pieces) at the two ends so that the magnetic lines of force are continuous throughout the body of the combination.

26. *How can a magnet be effectively demagnetised ?*

Ans. (i) : Heat the magnet to the Curie Point and then allow it to cool while lying in E—W direction.

[**Note** : This method may spoil the material of the magnet.]

Ans. (ii) : Place the magnet inside a solenoid kept in E—W direction. With the help of a transformer pass an A C. through the solenoid at 12—24 volts. After sometime slowly remove the magnet far away from the solenoid.

27. *Why are most of the lines of force, due to a magnet, curved ?*

Ans. A magnetic line of force is defined as the path along which a unit north pole will travel in a magnetic field. Consider a point P somewhere in the field of the magnet NS (Fig. 5-8). Imagine a unit north (or $+1$) pole placed at P. Under the influence of N-pole alone, the $+1$ pole at P will travel along NPQ, and under the sole influence of S-pole, along PS. Under the combined influence of both the poles, the $+1$ pole at P will move along the direction PR of the resultant intensity at P. But the moment the unit north pole starts moving along PR, the direction of the resultant intensity changes and this change of direction continues as the unit north pole moves onwards. This results in a curved line of force, starting from N-pole and ending on S pole.

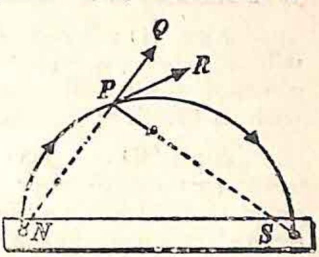

Fig. 5-8

[**Note** : PR is tangential to the magnetic line of force.]

28. *Why can't two magnetic lines of force intersect ?*

Ans. A magnetic line of force is the path along which a unit north pole travels in a magnetic field and the tangent to it at any point gives the direction of the resultant magnetic intensity at that point. And suppose that two magnetic lines of force intersect at some point. Then at the point of intersection, there will be two different tangents (to the two lines of force) representing two different directions of magnetic intensity which is impossible. Moreover, $+1$ pole placed at their point of intersection can never travel simultaneously along two different tangents or paths. Hence the two magnetic lines of force either should coincide and become one path or should not intersect.

[**Note** : This applies to electrical lines of force also.]

29. *What are ferro-, para-, and dia-magnetic substances ?*

Ans. The three substances—*iron*, *nickel* and *cobalt*—are so vastly more magnetic than any other substance that they are placed in a group by themselves ; they are said to be **ferro-magnetic.** The permeability of iron is as great as 2000, that of nickel 300 and of cobalt 250. No other substance has permeability approaching these, in fact its value in all other cases is very nearly unity. Nevertheless, nearly all substances have feeble magnetic properties. **Para-magnetic substances** (*e g.* tungsten, aluminium, manganese, chromium and oxygen) *have a permeability greater than unity and* **dia-magnetic substances** (*e g.* bismuth, zinc, copper, antimony, lead, mercury, water, and alcohol) *a permeability* less than unity.*

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*μ represents permeability in the relation $F=\frac{1}{\mu}\times\frac{m_1\times m_2}{r^2}$ while k is susceptibility in the relation $\mu=1+4\pi k$. Thus magnetic susceptibility will be positive for para-magnetic substances and negative for dia-magnetic substances.

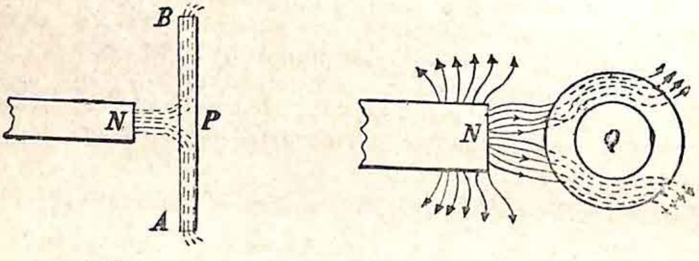
30. *How will you distinguish a dia-magnetic substance from a ferro-magnetic or a para-magnetic substance ?*

Ans. (i) : A rod of a ferro-magnetic or para magnetic substance will set, when suspended in a magnetic field, with its length in the direction of the field while a rod of a dia-magnetic substance will set with its length at right angles to the field.

Ans. (ii) : A piece of a ferro-magnetic or a para-magnetic substance tends to move from the weaker to the stronger parts of a magnetic field while a piece of a dia-magnetic substance tends to move from the stronger to the weaker parts of the field.

31. *What is magnetic screening ?*

Ans. It is the phenomenon in which a magnetic substance acts as a screen in a magnetic field. Best results will be obtained on using soft iron, possessing maximum permeability. If we place a soft iron plate AB in the field of a magnet, there will be re-distribution of lines of force such that maximum lines of force are concentrated within the plate and no line of force passes straight through it (Fig. 5-9-*a*). Thus the space P on the right hand side of AB is shielded from the magnetic effect of the magnet. [This can be verified by placing a compass needle on the side of P ; the needle remains unaffected and continues to point north-south.]



(*a*) Fig. 5-9 (*b*)

32. *What is the use of magnetic screening ?*

Ans. If a mag. compass is placed inside a stout soft iron ring or shell Q, the earth's magnetic field does not affect it. Fig. (5-9-*b*) shows how the magnetic lines of force are distorted away from the inside of the ring. Apparatus which must be operated in the absence of a magnetic field is shielded in this way by surrounding it with soft iron. Watches kept inside an outer soft iron ring become anti-magnetic.

[**Note** : (*i*) Conduct your magnetic experiments well away from other magnetic materials (*e.g.* gas pipes, retort stands) in the laboratory. Check that there are no iron pipes under the surface of the table.

(*ii*) Electric lines of force can not pass through an earth-connected conductor. It is known as *electrical screening*.]

33. *Is it possible to use a mariner's compass in a submarine ?*

Ans. *No.* The reason is that the submarine has an enclosing shell of *iron* which shields the compass from the influence of the earth's magnetic field. Consequently, the compass will not work at all due to magnetic screening. It will rest in any direction.

[**Note** : A mariner's compass is disturbed by the ship's magnetism. This effect on the compass can be eliminated by placing two soft iron spheres, one on each side of the compass and on a level with it.]

34. *While tracing a magnetic field, why is the compass needle suddenly reversed in direction as it crosses the neutral point ?*

Ans. Near the magnet, its field (F) predominates while farther from the neutral point the earth's magnetic field (H) predominates. Since the compass needle will show the direction of the resultant field at any point, these directions are diametrically opposite to each other for two points, one on each side of the neutral point. Hence the above mentioned behaviour of the compass needle on crossing the neutral point.

[**Note** : There is greater friction between the iron filings and the paper than between the compass needle and its pivot. That is why if the magnetic field is plotted with a small plotting compass, the field is found to be more extensive than is shown by the iron filings.]

35. *What is the difference between a neutral point and a null point ?*

Ans. At a *neutral point*, the magnetic field of the magnet is completely neutralized by the earth's horizontal field. There is *no resultant field* at such a point and a compass needle placed at that point points in any direction.

At the *null point*, the field due to one magnet is balanced by the field due to another magnet. The resultant field at such a point is the earth's horizontal field and the compass needle in this position will stay in the magnetic meridian.

[**Note** : (*i*) If the earth's field somehow vanishes, there will be nowhere a neutral point.

(*ii*) If the magnet is reversed pole for pole at a neutral point, the resultant field at that point then will be $2H$.]

36. *The compass box of a Deflection Magnetometer is of brass or any other non-magnetic substance. Will there be any harm if the compass box is made of, say, iron ?*

Ans. *Yes*, there will be an appreciable harm. The permeability of iron is very high. Hence, the lines of force due to the earth's magnetic field (H) as well as those due to the magnetic field (F) of the magnet kept on the arm of the magnetometer shall all tend to pass through the iron box. Consequently, there will be no lines of force inside the box and the needle will be *screened* from the influence of H as well as of F. The magnetometer will thus be rendered useless.

37. *Why should the magnetic needle in the Deflection Magnetometer be small? Can't we use a long needle and do away with the pointer?*

Ans. Working of a Deflection Magnetometer is based on *Tangent Law* which requires two mutually perpendicular and uniform magnetic fields acting on the magnetic needle. Of course, a needle, whether short or long, will always move in a uniform field (H) due to earth, but the field (F) due to a bar magnet can be taken approximately uniform *at long distances* from it and *over small areas only* (in reality we calculate F at the centre of the needle). Obviously, a long needle shall not move in a uniform field of a bar magnet. Hence we can not use a long needle and therefore we have to use a long and light pointer of aluminium in order to read deflections (of the needle) more conveniently and accurately.

38. *There will be deflection in the needle of a Deflection Magnetometer even if the field due to the bar magnet used is non-uniform. Then why should we insist that this field be necessarily uniform?*

Ans. The aim of using a Deflection Magnetometer is not only to get somehow a deflection in the magnetic needle, but the deflection should be according to some law whereby calculations to obtain the value of some unknown quantity can be made. In the present case, the needle should obey Tangent Law.

39. *For comparing the magnetic moments with the help of a Deflection Magnetometer, which method is better - deflection or null? And why?*

Ans. *Null method is better* than deflection method because it is easier and more accurate to see than to read a deflection. In deflection method, we have to read the deflection of the magnetic needle and there is always some error in reading a deflection on account of instrumental limitations. On the other hand, in null method the needle will show zero deflection, *i.e.* it will remain in its original position and the eye is very sensitive for noticing even a very small deflection.

Moreover, any factor which causes a change of deflection will produce the same effect on both the magnets in null method and hence this effect will be neutralized.

40. *While using a Deflection Magnetometer, which setting will you prefer—Tan-A or Tan-B? Is there any special reason for this preference?*

Ans. *Tan-A setting* (or First Position of Gauss) *is preferred* to Tan-B setting (or Second Position of Gauss). The reason is that in Tan-A setting we use a bar magnet on the arm of the magnetometer in such a way that the centre of magnetic needle lies at its axial line and it produces a field intensity $F_1=2M/r^3$ at the centre of the magnetic needle. But in Tan-B setting the same magnet has the centre of the magnetic needle lying on its equatorial line so that its field intensity $F_2=M/r^3$ at the centre of the needle located at the same distance r. If the needle shows deflections θ_1 and θ_2 in the two settings respectively, then

$$F_1=\frac{2M}{r^3}=H.\tan\theta_1 \quad \text{and } F_2=\frac{M}{r^3}=H.\tan\theta_2$$

$$\therefore \qquad \frac{F_1}{F_2}=\frac{\tan\theta_1}{\tan\theta_2}=2 \qquad \text{or} \qquad \theta_1>\theta_2$$

Since the deflection in Tan-A setting will be greater than that obtained in Tan-B setting, there will be less percentage of error in reading the deflection in Tan-A setting and thus the accuracy of the result will be enhanced.

[**Note** : It is wrong to say that $\theta_1=2.\theta_2$ unless the angles are very small, since in that case $\tan\theta=\theta$. But small angles we do not want. Why ? See Q. 41.]

41. *What are the limits between which you would like the deflections to lie while using a Deflection Magnetometer ? And why ?*

Ans. The deflection should preferably lie between 40° and 55°. The reason is that the variation in the value of $\tan\theta$ is large when θ is small as well as when θ is large. Hence the deflection should neither be too small nor too large. If the deflection lies between 40° and 55° and even if we commit an error of 1° in its measurement, the error in the result is nearly 3%. (In actual practice, the error in reading a deflection is less than 0 5°). If the angle lies outside these limits, the error is considerable.

42. *Why and what is the ideal value for deflection in the case of a Deflection Magnetometer ?*

Ans. It is 45°. When the deflection of the needle has this value, the error shall be minimum. For

$$F=H.\tan\theta$$

$$\text{or} \qquad dF=H.\sec^2\theta.d\theta$$

$$\therefore \qquad \frac{dF}{F}=\frac{\sec^2\theta}{\tan\theta}.d\theta=\frac{2}{\sin 2\theta}.d\theta$$

For maximum accuracy, dF/F must be minimum which is possible only when $\sin 2\theta=\text{maximum}=1$ or $2\theta=90°$, or $\theta=45°$.

43. *A powerful magnet is kept on one arm of a Deflection Magnetometer. Can the needle deflect through 90° ? Explain.*

Ans. Under no condition, the needle can deflect through 90°. Using the relation based on Tangent Law :

$$F=H\tan\theta$$

since tan 90° = infinity, therefore the field intensity F of the magnet at the centre of the needle will also be infinite which is impossible, howsoever powerful a magnet may be.

44. *A powerful magnet is kept on one arm of a Deflection Magnetometer. Can the needle still show the deflection of 0° ? Explain.*

Ans. Deflection of 0° means that the needle stays along the direction of H. This is possible only when the given magnet produces at the centre of the magnetic needle its field F : (i) along the direction of H so that the resultant field becomes $(H+F)$ or (ii) opposite to H but less than H so that the resultant field $(H-F)$ is still along H. This aim is achieved when the given magnet is placed (at a suitable distance) perpendicular to the arm of the magnetometer in Tan-A setting or parallel to the arm of the magnetometer in Tan B setting (Draw diagram yourself).

45. *A powerful magnet is kept on one arm of a Deflection Magnetometer. Can the needle deflect through 180° ? Explain.*

Ans. Deflection of 180° means that the poles of needle exchange their positions. This is possible only when F is opposite to H and is greater than H so that the resultant intensity becomes $(F-H)$. For this purpose, the given magnet is kept on the arm of the magnetometer (at a suitab'e distance) perpendicular to the arm of the magnetometer in Tan-A setting or parallel to the arm of the magnetometer in Tan-B setting such that its N-pole points towards north in Tan-A setting and towards south in Tan-B setting.

46. *For a Vibration Magnetometer, what considerations will you have for the selection of the material for suspension and which will be a good choice ?*

Ans. In the formula for the time period of a vibrating magnet, it is assumed that the only couple acting on the magnet and influencing its motion is earth's horizontal field (H) alone. The torsional reaction due to suspension is supposed to be negligible. Thus a *long unspun silk fibre*, which has a very small torsional reaction, is employed. However, a *horse-hair* is always to be preferred since there is no initial twist like that to be found in the silk fibre ; moreover, it is strong enough to bear the weight of the magnet.

[**Note** : Suspension cannot be of cotton which is hygroscopic and also twists easily.]

47. *In a Vibration Magnetometer, can't we use a fine metallic wire which will have no twist and the twist-removing operation need not be done ?*

Ans. It is true that in this case, there will be *no initial twist* in the suspension wire. But this suspension will be absolutely useless since at the latter stage when the magnet will perform oscillations, the wire will get twisted and there will be a torsional couple acting on the wire, which will tend to bring back the magnet. Thus the formula for the time-period will not be valid.

48. *Will there be any difficulty if the vibrating magnet is not perfectly horizontal in the stirrup of a Vibration Magnetometer ? Explain.*

Ans. *Yes*, there will be two-fold difficulty. Firstly, according to the formula, the magnet should oscillate in the horizontal component (H) of earth's magnetic field. Hence, the use of the formula in this form shall be justifiable only when the vibrating magnet is truly horizontal.

Secondly, the axis of rotation (*i.e.* the suspension fibre) should pass *vertically* through C.G. of the vibrating magnet since the formula for the moment of inertia of the magnet used here is derived for this mode of vibration of the magnet.

49. *Suppose, instead of putting the vibrating magnet flat in the stirrup, it is placed on its length and thickness. Will its time-period change and in what manner?*

Ans. *Yes*, its time-period will change. The time-period of a vibrating magnet is dependent not only on M and H (which remain constant here) but on its moment of inertia (I) also. Formerly, I depended upon the length and breadth of the magnet; now it will depend on its length and thickness (its mass remaining constant). Since the breadth of a magnet is usully more than its thickness, hence its moment of inertia will diminish in the second case; consequently, the *time-period will be reduced* (from the formula $t=2\pi\sqrt{I/MH}$).

50. *Why is the stirrup in a Vibration Magnetometer made of a light substance?*

Ans. In the formula for a vibrating magnet, the moment of inertia of the stirrup has been neglected. Hence the mass of the stirrup should be negligible in comparison with the mass of the magnet. Or better still, this type of stirrup should be removed altogether and the magnet suspended in a double loop made at the end of suspension fibre.

51. *Suppose we have two similar magnets. How will you judge which of the two is a stronger magnet without the aid of any third magnet but the earth?*

Ans. The time-period of a vibrating magnet is :

$$t=2\pi\sqrt{\frac{I}{MH}}=2\pi\sqrt{\frac{I}{2l.m.H}}$$

Since I, l and H are same for both the magnets, hence their time-periods will be inversely proportional to the square root of their pole-strengths (*i.e.* the stronger the magnet, the less will be the time-period) Hence, in order to find out which one of the two magnets is stronger, measure their time-periods when oscillating in a Vibration Magnetometer turn by turn in the earth's field. The one with *less time-period* will be stronger of the two.

52. *To keep the field uniform, a short magnetic needle is used in the Deflection Magnetometer. But the vibrating magnet is fairly large in the Vibration Magnetometer. Why should we not object to this?*

Ans. For the Deflection Magnetometer, see answer to Q. 37 above.

In the Vibration Magnetometer also, the oscillating magnet vibrates in a uniform field, which is provided by the horizontal component (H) of earth's magnetic field. Even if the magnet is a long one, it executes its oscillations in a uniform field since H is uniform over a sufficiently wide area in a locality.

[**Note** : Same reason applies to the use of a long needle in a Dip Circle.]

53. *How will the deflection and vibration magnetometers behave at the poles of the earth's magnet ?*

Ans. At the magnetic poles (where dip is 90°), the value of H is zero ($\because H=R.\cos\phi=R.\cos 90°=0$). Hence, no restoring couple ($=M.H.\sin\theta$) will be available for the needle of the deflection magnetometer. Consequently, the needle will take up any position it likes, and when the deflecting field (F) will he applied, the needle will set itself parallel to the lines of force of this field (F).

Similary, when the magnet is placed in the vibration magnetometer, it shall execute no oscillations.

54. *Since a compass does not point true (or geographical) North, how are ships steered accurately by its use ?*

Ans. The error or deviation of a compass increases as it approaches the poles and an allowance has to be made for what is known as the angle of *declination*. This value is shown on declination (or magnetic) charts to which navigators refer when steering ships by the magnetic compass.

55. *A compass needle is horizontal, but a dip needle is not so. Both are magnets. How can you justify their different behaviours in the earth's same magnetic field ?*

Ans. A compass needle rests on a vertical pivot and can thus rotate in the horizontal plane only under the action of horizontal component (H) of earth's total intensity (R).

On the other hand, a dip needle is suspended about a horizontal axis and is free to move in all directions in the vertical plane. The needle will naturally point in the direction of the earth's total or resultant magnetic intensity (R). And in the northern hemisphere the effect of the north-seeking pole is stronger (on the dip needle) than that of the south-seeking pole in the southern hemisphere, which causes the needle to dip because of its proximity to one pole or the other. Evidently, the needle will dip its north-pointing end in the northern hemisphere and its south-pointing end in the southern hemisphere.

56. *A bar magnet is held in a vertical position at the earth's magnetic equator. What are the forces acting on the magnet ?*

Ans. At magnetic equator, the value of vertical component (V) of earth's total intensity (R) is zero and only the horizontal component (H) acts on the magnet (Fig. 5-1). Hence two horizontal forces ($m.H$, mH) act on the poles of the magnet constituting a couple whose moment$=mH \times 2l = M.H$.

57. *A bar magnet is held in a vertical position at Delhi. What are the forces acting on the magnet?*

Ans Delhi is situated neither at the magnetic equator nor at the magnetic North or South pole of the earth. Hence the given vertical magnet will be acted upon by the resultant Intensity (R) of the earth's magnetism. If dip at Delhi be $\phi°$, then the two forces (mR, mR) acting on the magnet will be inclined at an angle ϕ to the horizontal (Fig. 5-1) and the moment of this couple$=mR \times 2l \sin(90-\phi) = M.R.\cos\phi$.

58. *What direction will a dip needle show if placed at a neutral point?*

Ans. At a neutral point, the field of the magnet is neutralized by the horizontal component of earth's field. Therefore, the magnetic field left at the neutral point will be the vertical component of earth's field which will urge the dip needle to become *vertical*.

59. *Why is liquid used in a mariner's compass?*

Ans. The liquid damps the movement of the disc (beneath which are symmetrically fixed a number of light magnets), *i.e.* prevents it from swinging about too much. Secondly, the liquid by its buoyancy takes away some of the weight of the disc from its pivot thereby reducing friction.

[**Note** : Generally the liquid used is water with which alcohol has been mixed to prevent it from freezing.]

Part VI—Electrostatics

Concise Electrostatics

1. Electrostatics : Modern theories of electricity state that electric charges are an essential part of matter. These charges can be of two kinds—positive and negative. The study of electric charges at rest is called *Electrostatics*.

2. Production of static electrical charges : If a glass rod is rubbed with silk, the glass becomes *positively* charged and the silk *negatively* charged.

If a rod of ebonite is rubbed with fur, the rod becomes *negatively* charged and the fur *positively* charged.

There is always an equal and opposite production of two charges simultaneously.

3. Conductors and Insulators : Substances which allow the full passage of electric charges through them are called *conductors*, and substances which do not allow charges to pass are called *insulators*. In-between them come partial conductors or partial insulators.

All metals are conductors, the best good conductors being gold, silver, copper, aluminium, green vegetation and ordinary water. The good insulators are paraffin, mica, ebonite, porcelein, rubber, sulphur, silk, glass, dry air and distilled water. Under partial conductors come ivory, marble, cotton, paper, etc.

4. Coulomb's Laws : (*i*) Like charges repel and unlike charges attract each other along the straight line joining these charges.

(*ii*) The force of repulsion or attraction between two charges is directly proportional to the product of their strengths and inversely proportional to the square of their distance apart.

5. E.S.U. of Charge : It is that much charge which when placed in air at a distance of one cm. form an equal and similar charge is repelled with a force of one dyne. Practical unit of charge is coulomb :

$$1 \text{ coulomb} = 3 \times 10^9 \text{ e.s.u. of charge.}$$

6. Potential : It is the degree of electrification (as temp. is the degree of hotness) of a body which determines the direction of flow of charge when this body is brought in metallic contact of another body. The charge always flows from a body at higher potential to the body at lower potential, without caring for the quantities of charges at the two bodies, till both attain the same potential.

The potential at any point is the amount of work done in bringing a unit positive charge from infinity to that point, and *is* *independent of the actual path taken by the unit charge* (otherwise energy could be obtained by taking the charge along one path and allowing it to return along another path where less work would be done when the charge is taken along it).

$$\text{Potential at a point} = \frac{\text{Charge}}{\text{Distance of this point from the charge}}$$

The *potential of earth is zero.* Positive charge flows from higher potential to lower potential, and negative charge in the reverse direction till mutually connected bodies come at the same potential.

All points on the surface of a conductor are at the same potential.

A hollow charged conductor encloses an *equipotential space.*

Potential, like work, is a *scalar* quantity. But no work is done in moving a charge across an equipotential surface.

7. **Distribution of Electric Charges** : (*i*) Charge always resides on the outer surface of a conductor.

(*ii*) If the surface of a conducting body is not plane or not of same curvature, then the charge is not equally distributed. There is more charge per sq. cm. of surface in an area which is sharply curved—the sharper the curve, the greater the charge density (*e.g.* charge density is more on conical points).

Charge gradually leaks through sharp points by creating a similarly charged *electric wind.* This behaviour of charged points is fully utilized in lightning conductors and Wimshurst machine.

8. **Electrostatic Induction** : A previously uncharged conductor can be given a charge by the process of induction *without touching* a charged body. In the presence of the charged body (or inducing charge), the conductor is touched by hand in order to connect it to the earth. Then remove the hand first and then the inducing charge. The conductor will thus be charged ; its charge will always be opposite to the inducing charge.

(*i*) The induced −ve and +ve charges are always equal in amount.

(*ii*) When the inducing charge is completely surrounded by a (hollow) conductor, then each of the induced charges is equal to the inducing charge (Faraday's Ice-Pail Experiments).

Note : Charges can not be induced on non conducting bodies.

9. **Electrostatic Field and Lines of Force** : The area or space over which a charge or charges can exert a force on other charges is called an *electrostatic field.* Like a magnetic field, it has lines of force. The **properties of electrical lines of force** are :

(*i*) They start from (the surface of) positive charge and terminate on (the surface of) negative charge if available in the vicinity, otherwise on the walls of the room.

(*ii*) The number of lines of force which cross a unit area perpendicular to the field indicates the strength of the field at that point.

(*iii*) Positive charges always try to move down the lines of force, *i.e.* from positive to negative ends and negative charges move up.

(*iv*) Lines of force are always *perpendicular* to the surface of the conductor.

(*v*) They can pass through insulating materials, but not through earth-connected conductors.

(*vi*) Equal and opposite charges are distributed at the two ends of each line of force.

(*vii*) Lines of force do not intersect one another.

(*viii*) Lines of force tend to contract lengthwise and expand at right angles (laterally) to one another.

The lines of force are all imaginary and have been supposed to explain the electrical phenomena.

10. Gold-leaf Electroscope : It is of great practical importance and can be made into a precision instrument. It can be used as a detector of *electric charge* or of *potential.* The deflection or divergence of the leaves is proportional to the potential of the body to which it is connected when its tin-foils are connected to earth.

The divergence of gold leaves is due to the difference of potential between the leaves and its metallic coatings. The charge on the leaves is not the decisive factor.

The divergence of the leaves indicates a quantitative measure of the charge given to the electroscope.

11. Capacity (or Capacitance) of a Conductor : It is equal to the ratio of the charge and potential of the conductor. It is also defined as numerically equal to that quantity of charge which must be given to a body to raise its potential be unity.

The practical unit of capacity is *farad*, which is the capacity of a conductor which needs one coulomb of charge to increase its potential by one volt.

$$1 \text{ farad} = \frac{1 \text{ coulomb}}{1 \text{ volt}} = \frac{3 \times 10^9 \text{ e.s.u. of charge}}{1/300 \text{ e.s.u. of potential}}$$

$$= 9 \times 10^{11} \text{ e.s.u. of capacity.}$$

12. Capacity of a Sphere : It is numerically equal to its radius. Evidently, a sphere of 1 farad capacity will have a radius of 9×10^{11} cm. which is 1400 times the radius of earth. Consequently, we must devise a method of increasing the capacity of a conductor without unnecessarily increasing its size. And the answer is the condenser.

13. Potential Energy of a Charged Conductor is the amount of work done in charging the conductor.

$$P.E. = \tfrac{1}{2}\, Q.V = \tfrac{1}{2}\, C.V^2 = \tfrac{1}{2} Q^2/C$$

There is always a loss of energy when the charges are shared, which appears in the form of heat or as sparks accompanied by sound.

14. Condenser (or Capacitor) : It is an arrangement of having one plate charged and the other earthed with a dielectric in-between them. It is used for increasing the capacity of the insulated and charged plate or conductor.

Charge resides on the solid dielectric of a condenser.

15. Lightning : Lightning usually hits things that are sticking up into the air. It often hits trees. If you can not run home, it is better to lie down in a low, open place. A motor car is a safe place and so is a cave.

Lightning often strikes water, so you should not swim during a thunder storm.

Objective Type Questions

CHAPTER XXXVI

INTRODUCTION

I. Completion Test :

(1) Electrostatics is so called because...

(2) When two bodies are rubbed together...produced are . ...in amount but are of...nature.

(3) ...is a surer test of electrification.

(4) The charge on the electrons is...

(5) Electric current is caused by the...of electrons.

(6) When a glass rod is rubbed with a silk piece,......electricity is produced on glass and —ve electricity is produced on ebodite rod when this is rubbed with......

(7) ......are those which allow the electricity to pass through them and...are those which do not allow the same.

(8) ...precedes attraction.

(9) There is .....of electrons in the glass rod and...of electrons in the silk piece when the glass rod is rubbed with a silk piece and electricity is developed.

(10) ......gave the +ve and—ve names to the two kinds of electrical charges.

II. Selection Test :

(1) ...is the process of acquiring temporary electrification under the influence of a charged body.
[Attraction, Induction, Repulsion]

(2) Each type of...charges is equal to the...charge.
[induced, inducing, attracting]

(3) In the process of induction,......kind of charge is induced on the farthest end while......kind of charge is induced on the nearest end of a body.
[opposite, same]

(4) Charge on the...body remains the same during the process of induction.
[induced, inducing, solid]

(5) ...resides on the...surface of a charged conductor.
[charge, current, outer, inner]

(6) Static-electricity is produced by......
[induction, friction, battery, simple cell]

III. Tick-Mark Test (*for choosing correct statements*) :

(1) Charge resides on the inner as well as the outer surface of a conductor.

(2) Surface density of charge is the amount of charge on a unit area of the surface.

(3) Induced charges are of opposite nature.

(4) Induction does not occur in insulators.

(5) Copper is a good conductor of electricity.

(6) Pith-ball pendulum is used for detecting the charge on a body.

(7) For finding the value of "*g*" at a place, we use pith-ball pendulum.

(8) We remove our hand first and then the charged body when we charge the Gold-leaf Electroscope by induction.

(9) Sharper is the curvature of a spot on a charged body, greater will be the surface density of charge at that point.

(10) When a charged body touches a hollow conductor from inside, it loses whole of its charge.

(11) The distribution of the charge on a conductor depends upon its shape and position.

(12) Gold-leaf Electroscope is used for detecting the nature and presence of charge on a body.

IV. Distribute the following into conductors and insulators :

Dry wood ; Glass ; Amber ; Silk ; Water ; Human body ; Dry air ; Copper ; Gold ; Oils ; Solution of cammon salt ; Mercury ; Rubber gloves ; Carbon.

CHAPTER XXXVII

ELECTRIC FIELD AND POTENTIAL

I. Completion Test :

(1) The inverse square law in electrostatics was discovered by......and verified experimentally by......

(2) The force of......or......between two charges is......proportional to the......of their charges and... ..proportional to the......between them.

(3) *K* in electricity is called......and *K* for air is......

(4) Electric lines of force start from......charge and end at...... charge.

(5) In the electric field, the lines of force......longitudinally and ......laterally.

(6) Force experienced by a unit +ve charge when placed at a point in an electric field is called......at that point.

(7) Force experienced by a stationary charge '*q*' placed in an electric field of intensity *E* is......

(8) 1 volt=...... e.s.u. of potential and 9×10^9 e.s.u. of charge =......coulombs.

(9) 1 coulomb=charge on......electrons.

(10) Corresponding to temp. in heat, we have......in electrostatics,......in liquids and......in gases.

(11) Charge always flows from......to......potential.

II. Selection Test :

(1) Potential is a......quantity and field intensity is a...... quantity. [scalar, vector, neutral]

(2) A gold-leaf electroscope measures......of a conductor. [charge, potential]

(3) Earth is at......potential. [zero, infinite, −ve, +ve]

(4) On the surface of a charged conical conductor, the potential is ... [uniform, non-uniform]

(5) A unit electric charge is that much charge, which repels another equal and similar charge placed in air at a distance of...... with a force of...... [one, two, three, dyne, newton, cm, inch]

(6) When the proof plane is first touched with a charged body and then with the disc of a G.L. electroscope, the divergence of leaves will show ..... [charge, potential, charge density]

(7) A proof plane connected with the disc of a G.L. Electroscope is moved over the surface of a charged body. The divergence of leaves will show......of the body. [quantity of charge, potential, density of charge]

(8) Lines of force ......cut one another. [always, never, sometimes]

(9) Two charged metal spheres mounted on insulating supports are connected by a wire through a galvanometer. As a large uncharged metal sheet is bought near one of the spheres, a momentary current is observed through the galvanometer. The principle directly useful in explaining this is......

(*a*) the greater the curvature of the surface of a conductor, the greater the density of the electric charge.

(*b*) a moving electric charge produces a magnetic field.

(*c*) the potential of a conductor depends on its distance from other charged conductors.

(10) A negatively charged particle is placed on a st. line joining two other stationary particles, each having a charge $+q$. The direction of motion of the negatively charged particle will depend on...

(*a*) the magnitude of the charge.

(*b*) the position at which it is placed.

(*c*) both magnitude of charge and its position.

III. Choose the correct statements :

(1) Gold-leaf electroscope measures potential.

(2) We can have a +vely charged body at

(*a*) +ve potential, (*b*) −ve potential, (*c*) zero potential.

(3) We can have an uncharged body at

(*a*) +ve potential, (*b*) −ve potential, (*c*) zero potential.

(4) Electric lines of force start from +ve charge and end at −ve charge if available, otherwise on the walls of the room.

(5) An equipotential surface is that surface, on which each and every point has the same potential.

(6) Potential at a point is the amount of work done in bringing a unit +ve change from infinity upto that point against or by the electrical forces.

(7) A small sphere has got a higher potential than a large sphere, when the charge on both is same.

(8) Coulomb's Laws can be verified by a Torsion Balance.

(9) Same kind of charge is given to a G.L. Electroscope on charging it by conduction and opposite charge is given when it is changed by the process of induction.

(10) Electrification without touching is called induction.

(11) There is no charge inside a hollow conductor.

CHAPTER XXXVIII

CAPACITY AND CONDENSERS

I. Completion Test :

(1) Capacity of a conductor$=\dfrac{\cdots\cdots}{\cdots\cdots}$.

(2) Capacity of a spherical conductor is numerically equal to its .....

(3) Capacity $C=\frac{\cdots\cdots}{\cdots\cdots}$, for a parallel plate condenser.

(4) Capacity $C=\frac{\cdots\cdots}{\cdots\cdots}$, for a spherical condenser.

(5) Leyden jar is a......condenser.

(6) 1 farad=......e.s.u. of capacity, and 1 $\mu\mu f=\ldots\mu f=\ldots f$.

(7) The capacity of a parallel plate condenser......when a glass slab replaces air in-between the two plates.

(8) The seat of charge in the case of a condenser is its......

(9) There always occurs a......of energy, when sharing of the charges takes place between two or more conductors.

(10) ......is a practical unit of capacity.

II. Choose the correct statements :

(1) When a charge of 1 e.s.u. raises the potential of a conductor by 1 e.s.u., the conductor is said to possess a capacity of 1 e.s.u.

(2) A conductor has a capacity of 1 farad when a charge of one coulomb raises its potential by 1 volt.

(3) When three condensers of capacities C_1, C_2, C_3 are joined in series, their effective capacity C is given by the relation :

$$\frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}$$

(4) When three condensers of capacities C_1, C_2, C_3 are joined in parallel, their effective or combined capacity C is given by the relation :

$$C=C_1+C_2+C_3$$

(5) Condenser is a device for storing the electrical energy.

(6) Capacity of a parallel-plate condenser depends on the metal used to make the plates.

(7) A sphere of capacity 2 farads can be given a potential of 2 volts by connecting it across a 2-volt battery.

(8) A sphere of capacity 2 farads can be given a potential of 2 volts by connecting it to the positive terminal of a 2-volt battery and earthing the other terminal.

(9) A sphere of capacity 2 farads can be given a potential of 2 volts by giving it 4 coulombs of charge.

(10) The capacity of a conductor decreases when an earth-connected conductor is brought near it.

III. Matching Test :

Column A	*Column B*
(1) Electric intensity at a point.	(*a*) radius
(2) Electric potential at a point.	(*b*) $\frac{1}{K} \cdot \frac{q_1 \cdot q_2}{r^2}$
(3) Capacity of a sphere.	(*c*) $0{\cdot}33 \times 10^{-2}$ e.s.u.
(4) Capacity of a Leyden jar.	(*d*) $\frac{C_1V_1+C_2V_2}{C_1+C_2}$
(5) Common potential (V) when two charged conductors are brought in contact.	(*e*) $\frac{Q}{V}$
(6) One volt equals	(*f*) q/r
(7) Relation representing Coulomb's Laws.	(*g*) q/r^2
(8) Capacity of a conductor.	(*h*) $\frac{KA}{4\pi t}$

CHAPTER XXXIX

INDUCTION MACHINES AND ATMOSPHERIC ELECTRICITY

I. Completion Test :

(1) ......was the first to prove that clouds are charged with electricity.

(2) Electrophorous is based on the process of......

(3) In the electrophorous, mechanical work is the source of ...

(4) Discharging of the two oppositely charged clouds causes ......

(5) In a Wimshurst machine, electricity is produced by ...... and not by ......

(6) ...... cause the rumbling of sound of thunder.

(7) Electricity ...... on the moist day.

(8) Lightning conductor is used to ...... high buildings.

(9) Van de Graaff's Generator is used for the production of ...... voltage.

(10) For increasing the capacity of the discharging knobs, ... are used in the Wimshurst machine.

II. Selection Test :

(1) There is —ve charge on ...... [protons, neutrons, electrons]

(2) The potential ...... when two charged drops unite. [falls, rises, equals]

(3) A potential acquired by a body due to the neighbouring charges is called ...... potential. [induced, free, inducing]

(4) When the charges are shared, energy is ...... [gained, lost, zero]

(5) The plates of the Wimshurst machine move in the ...... directions. [opposite, same, parallel]

(6) A Wimshurst machine ...... work in vacuum. [can, cannot]

(7) Better regulation is possessed by ...... [Van de Graaff's Generator, Wimshurst machine, clouds]

(8) Van de Graaff's Generator can start working......giving an initial charge. [with, without]

III. Choose the correct statements :

(1) During a thunder storm, we should stand under a tree.

(2) Copper rod is used for making lightning conductors.

(3) Velocity of light is much greater than that of sound.

(4) When evaporation of water takes place from a pond of water, water vapours carry +ve charge and water left behind is having a —ve sharge.

(5) By the friction of the strong air currents in the atmosphere, suspended drops of water become charged.

(6) Cosmic rays from the outer space bombard the atmosphere continuously.

(7) For transferring the charge, we use proof-plane.

(8) Discharging action of the sharp points and the collecting action of the spheres—is the principle of Wimshurst machine and Van de Graaff's Generator.

Short-Answer Questions

1. *What is the difference between static electricity and current electricity ?*

Ans. Modern theory of electricity states that electrical charges are an essential part of matter. These charges can be of two kinds — positive and negative. The study of electric charges at rest is called *Electrostatics* (or Static Electricity). In static electricity, charge flows away from a charged body through a piece of wire or other conductor till the potential is equalized. But in current-electricity it must be remembered that the charge is being supplied as fast as it is leaking away and thus a continuous "current" is being produced.

2. (*a*) *What is meant by an electric current ?* (*b*) *What is its practical unit ?*

Ans. **(a)** : Electric current may be defined as the flow or movement of electrons—negative electricity—from one atom to another of a conductor, this movement being induced either by artificial or by natural means.

(b) : Its strength is measured by the *rate of flow of charge*. Its practical unit is *ampere*. When a charge of 1 coulomb flows in a conductor in 1 second, the current is said to be 1 ampere.

[**Note** : Electric current is of two types—Alternating Current (A.C.) and Direct Current (D.C.).]

3. *Sometimes clicks are heard on combing our dry hair. Why ?*

Ans. When combing in the hair is done, friction takes place between the comb and the hair and by friction, equal and opposite charges are produced on them. Since unlike charges attract each other, the hair are attracted by the comb. As their opposite charges come closer, an electric discharge takes place and the discharge is accompanied by sound or clicks (just like thunder accompanying lightning).

[**Note** : On account of equal and simultaneous development of two kinds of charges, *the shavings are seen to cling to the knife while sharpening a pencil.*]

4. *Why do birds fly off a high-tension wire when the current is switched on ?*

Ans. When the high-tension (or strong) current is switched on, a charge of static electricity appears on the bird's body and feathers.

On account of repulsion between similar charges, the feathers spread away from the body. This causes the bird to fly away.

5. *Why does the current flow in a conductor but not in an insulator ?*

Ans. We know that current is due to the movement of electrons. Keeping in view the structure of atom, it can be said that there are some substances which have many *free electrons* in their outermost orbit. Almost no force is required to move them within the substance which, therefore, can conduct electricity from one point to another very easily. These are called *conductors.*

But sometimes, the outermost orbits are "complete" and no electron from such substances can be removed. These are called *insulators.* It is very difficult to transfer electricity through them and hence they are called *non-conductors.*

[**Note** : (*i*) There is a 3rd group of elements which are not good conductors but they cannot also be called good insulators. Very appropriately they are called *semi-* (or *partial*) *conductors* or *semi-insulators.*

(*ii*) All the three kinds of elements form crystals. The electrons in the atom can also be thought of a *cloud* of charge. (*a*) In a *conducting crystal,* the electronic charge-cloud of one atom *overlaps* to some extent with that of the next atome so that the charge-cloud of electrons pervades the entire regular crystal array. The outermost (free) electrons rather belong to the entire crystal lattice. This enables them to move freely within the crystal of conductors (*b*) In *insulators,* the electrons associated with each atom form a small localised charge-cloud. These individual charge-clouds do not merge into one another. An electric field, therefore, cannot move their electrons from one charge-cloud to the next very easily, unless an extremely high voltage is applied ; then the insulation is said to have "broken down". (*c*) In *semi-conductors,* electron charge-distribution around each atom *almost* touches the electron charge-distribution of the neighbouring atom, but not quite. This enables the electrons to jump across from one atom to the next occasionally.]

6. *What is the simplest method of distinguishing conductors from semi-conductors ?*

Ans. *If we heat a conductor, its resistance increases* as its temp. increases. This is because on heating, atoms move or vibrate about their mean position with an increased amplitude and jostle or interfere with the movement of electrons. This reduces the free movement of electrons on the application of an electric field.

In a semi-conductor on the other hand, an increasing temp. will cause greater vibrations of the atom and of the electron charge-cloud. This will bring neighbouring electronic charge clouds to come closer and finally merge into one another for a part of the time so that the electric current-flow becomes easier on the application of an electric field (or electrical potential difference). Thus *in a semi-conductor, resistance decreases when it is heated.*

7. *Why can't you electrify a metal rod by rubbing it while holding it in your hand? How would you then charge it?*

Ans. When we electrify a metal rod by rubbing it while holding in the hand, electricity will flow to the earth *via* our good conducting body. Thus no charge remains on the metal rod.

So in order to charge it, the metal rod should be insulated. It is done by attaching an insulating handle of wood, glass, etc.

8. *Why do steam road-vehicles running on rubber tyres always drag a chain along the ground?*

Ans. It is because steam, escaping from the safety and exhaust valves of a boiler, becomes, say, positively charged and the boiler (indeed the whole of the vehicle) negatively charged. The purpose of the chain is to conduct this excess of negative charge to earth. If this were not done, a shock would be experienced by anyone boarding the vehicle, the instant the hand touched it.

[**Note** : (*i*) When the gasoline tank of an aeroplane is filled, the metal nozzle of the hose is always carefully connected to the metal of the aeroplane by a wire before the nozzle is inserete in the tank. When the gasoline flows, the stream of liquid can become charged by friction with the nozzle. The charged gasoline would go into the plane and charge it oppositely to the nozzle. Unless a good conducting patch is provided so that the charges on the plane and the nozzle could recombine, a spark could result.

(*ii*) Charges develop when leather belts travel over iron pulleys.

(*iii*) Charges develop when paper in a printiug press is taken off the rollers.]

9. *Why are the hand-grip rails on motor buses usually wrapped round with insulating tape?*

Ans. It is because in dry weather, the friction of the tyres on the road, when running, charges up the chassis and metal-work of the vehicle and a shock would, under certain circumstances, be felt by boarding passengers. Such precautions are unnecessary on vehicles with metal wheels, as the excess charge leaks away to earth as it collects. The use of rubber road wheels prevents this leakage.-

10. *How is it possible that electric fishes can give shocks when in water which is a conductor of electricity?*

Ans. When the electric eel bends its body, so that its head and tail touch different parts of its prey, a very strong shock is given by contact. A living body is a much better conductor of electricity than ordinary water. The strongest shocks are more than sufficient to kill the prey, but repeated shocks will weaken the discharges.

11. *Why do experiments on electrostatics fail on a wet day?*

Ans. On a wet day, there is enough quantity of water vapours present in air. The non-conducting air becomes good conductor of electricity on account of water vapours. Therefore, when we charge a conductor on a wet day, its charge is at once taken by the moist air and thus it leaks away.

12. *If we are given an insulated charged sphere, we can charge, by induction, any number of other insulated conductors without affecting the charge of the sphere. Does this not violate the law of conservation of energy? If not, then what is the source of energy?*

Ans. The charged sphere induces opposite (and bound) charge on the nearest end of the conductor and similar (and free) charge on the farthest end. On touching this conductor with a finger, the free charge goes to earth. On removing the finger the conductor possesses opposite charge only. Therefore when this conductor is removed away from the charged sphere, we have to do some *mechanical work against the force of attraction* existing between unlike charges. It is this mechanical work which changes into electrical energy when various conductors are charged by induction with the help of one charged sphere. Hence this does not violate the law of conservation of energy.

[**Note** : Same reasoning applies to the electrophorous also, in which same quantity of charge is obtained many times from an ebonite cake charged once by rubbing it with a cat-skin.]

13. *Why can't insulators be charged by induction?*

Ans. In the case of conductors, a charged body during the process of induction is able to drive electrons from one part of the conductor to the other. But an insulator does not allow electrons to move from one part to the other, hence a charged body when brought near it will not be able to bring about a re-distribution of electrons. Hence charges cannot be induced on non-conducting bodies.

14. *Why should an electrical charge reside on the outer surface of a conductor?*

Ans. We know that like charges repel one another. When some charge is given to a conductor, like charges start repelling one another. This force of repulsion brings the electrical charges to the farthest boundary of the conductor, *i.e.* to its outer surface. Thus no charge can stay inside a conductor.

15. *Why does not a man sitting inside an insulated metallic cage receive any shock when the cage is gradually given a high charge?*

Ans. (**i**) ; We know that an electrical charge resides only on the outer surface of a conductor. Therefore, whatever charge is given to an insulated metallic cage, it does not go to or remain on the inner surface but it comes on the outer surface of the cage. Consequently, the man inside the cage will not receive any shock.

Ans. (**ii**) : Though there is no charge on the inner surface of the cage, but the potential of its outer surface is always equal to that of the inner surface or of any point inside it [because a hollow conductor encloses an equipotential space]. Since no potential difference

(P.D.) exists between the outer surface of the cage and the man sitting inside, hence no shock is experienced by this man.

[**Note** : But this man will receive a shock if somebody from outside touches this man, since the charge will now start flowing from this man to the earth through the connecting conductor. Therefore, you should never poke your finger inside a hollow current-carrying pipe.]

16. *How can a charged conductor give up all its charge to another insulated conductor* ?

Ans. (i) : If a charged conductor be *introduced into* another insulated conductor and brought into contact with the latter's inside wall, the charge will be *entirely* transferred to the outer surface of this second conductor (in accordance with Faraday's Ice-Pail Experiment).

Ans. (ii) : *If the inner radius of insulated conductor is exactly equal to the outer radius of the given charged conductor A*, then cut the insulated conductor into two hemispheres B and C (Fig. 6-1) and by holding them with the help of insulating handles, cover A by B and C so that the outer surface of A is no more the outer surface of the combination. Since the charge resides on the outer surface of the conductor, complete charge from A leaks or is transferred to the outer surface of B and C. Now with a jerk, separate B and C, and then combine them into one sphere, which has now got the total charge of A. [It is known as Biot's Experiment].

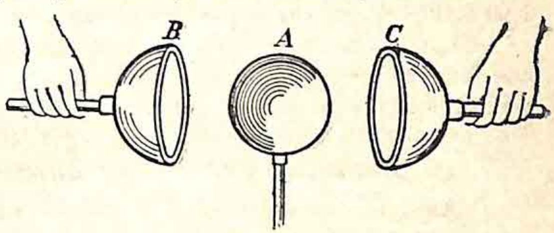
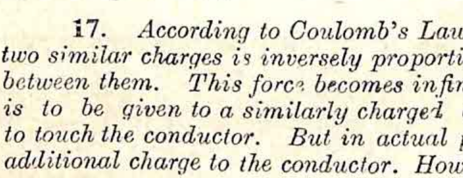


Fig. 6-1

17. *According to Coulomb's Law, the force of repulsion between two similar charges is inversely proportional to the square of the distance between them. This force becomes infinitely large when a small charge is to be given to a similarly charged conductor and the charge is about to touch the conductor. But in actual practice, one can easily supply additional charge to the conductor. How will you explain this anomaly* ?

Ans. In the beginning, the charge will get distributed over the surface of the conductor according to the surface density of the charge at various points. For a sphere this distribution is uniform (Fig. 6-2-*a*).



(*a*) Fig. 6-2 (*b*)

When another similar charge is brought towards the charged sphere, the charge-distribution does not remain uniform on account of repulsion between similar charges. This repulsion pushes away the charge on the sphere to its farthest side (Fig. 6-2-*b*) so that the distance between the approaching charge and that on the sphere never approaches zero and therefore the force of repulsion is not too large. After getting the additional charge, there is re-distribution of charge over the whole surface of the conductor.

18. *We know that a charged ball attracts a piece of paper. How will the force of attraction be altered if a metal sphere be placed around (a) the charged ball (b) the piece of paper ?*

Ans. (**a**) : *When the charged ball is surrounded by a concentric metal sphere*, an induced charge will appear on the inner surface of the sphere equal in magnitude, but opposite in sign, to the charge on the ball ; and also there will be a charge of the same magnitude and of the same sign as the ball's charge on the external surface of the sphere. This will create the same electric field in the space outside as the ball was creating before. Both the ball and the sphere act in the same way as a charge concentrated at the centre of the ball. Therefore, the *paper will be attracted by the ball* as before.

(**b**) : *When the piece of paper is surrounded by the metal sphere*, the force of attraction will be reduced to zero ; the induced charge will appear on the sphere but there will be *no field inside the sphere.* The metal sphere will be attracted to the ball, but not the paper.

19. *Mention the uses of a G.L. Electroscope.*

Ans. (*i*) To detect the *presence* of charge on a body.

(*ii*) To determine the *kind* of charge on a body.

(*iii*) To indicate roughly the *magnitude* of the charge.

(*iv*) To judge the *potential* of a charged body.

(*v*) To distinguish between an insulator and a conductor.

20. *Is it possible to measure the voltage of an A.C. circuit with an electroscope ?*

Ans. *Yes.* The leaves of an electroscope always move apart regardless of the sign of the charges on the leaf and the main body whose voltage is to be measured. In the case of A.C., during both half-periods, leaves will continue to show divergence. The divergence of the leaves will be proportional to the voltage of the A.C. circuit.

21. *The leaves of a G.L. Electroscope collapse slightly if the palm of the hand is held near its top but resume their original position when the hand is removed. How can you explain this behaviour of the leaves ?*

Ans. When the palm of the hand is brought near the disc of the charged electroscope, induction takes place. Opposite charge is induced on the lower side of the palm and similar charge on the upper side. This free similar charge goes to earth through our body and thus only opposite and bound charge stays on the hand.

Explanation (i) : This opposite charge on the hand attracts the charge spreading over the leaves, disc and the connecting rod. Thus more charge accumulates on the disc and less charge stays on the leaves—resulting in their slight collapse as the force of repulsion is directly proportional to the strength of charges on the leaves. When the hand is removed, the force of attraction also disappears and redistribution of charge takes place. Since the leaves get back their original charges, they resume their original position of divergence.

Explanation (**ii**) : The leaves and the disc are in the beginning at a particular potential which is decreased by the potential produced by the bound and opposite charge of the hand. Since the divergence of the leaves measures their potential when the tin foils of the electroscope are earth-connected, hence the leaves collapse slightly. [Such an electroscope having an earth-connected conductor near its disc is known as a *condensing electroscope*.]

When the hand is removed, the effect of the induced opposite charge of the palm vanishes, and the leaves restore their original potential as well as divergence.

22. *Irrespective of the shape of a conductor, why should its surface be always equipotential* ?

Ans. Although the surface density of charge (=the quantity of charge present on a unit area of a given surface) is more for sharp points and less for flat surfaces, yet the potential is same (or equal) everywhere on its suface. To justify this, let there be two points, on its surface, having unequal potentials Since these two points are connected to each other through the conducting surface of the conductor, the charge will start flowing from the point at higher potential to the other point at lower potential till the two points attain the same potential. That is, these two points cannot stay at different potentials. Same thing applies to all other points constituting the surface of the conductor.

[**Note** : The surface of a conductor, *on which electricity is at rest*, must necessarily be an equipotential surface.]

23. *Why are the electric lines of force at right angles to an equipotential surface* ?

Ans. Since the potential is same everywhere on the surface of an equipotential body, no potential difference exists between any two points situated anywhere on such a surface. Evidently, *no work* will be done in moving +1 or any other charge on this surface.

But $\quad$ work = force × distance

Since the distance between two points cannot be zero,

$\therefore \quad$ force = 0

i.e. no force acts along the surface of an equipotential body. It means that the real force whose one component along the surface is zero must be prependicular to the surface. In other words, the electric lines of force must be at right angles to the surface.

24. *A small metal ball is charged to a potential of +10 volts. It*

is introduced into a large hollow metal sphere charged to a potential of +1000 volts and comes into contact with the inside surface of the sphere. The ball's charge passes to the sphere—from a body at lower potential to that at higher potential, when exactly the opposite ought to take place. How will you explain this ?

Ans. In the space inside the large sphere, which is charged to a potential of +1000 volts, all points have the same potential of +1000 volts. When the small ball, charged to a lower potential of +10 volts, is introducd into this large sphere, work is done, as a result of which the small ball is also charged to a potential of +1000 volts. Thus when the ball is brought into contact with the inside surface of the sphere, the charge is transferred, at the same potential, from the inside surface to the outside surface of the conducting sphere.

25. *Why is the electric field inside a hollow conducting surface zero ?*

Ans. A hollow conducting surface encloses an equipotential space, therefore no potential difference exists between any two points situated anywhere inside the hollow conductor. Evidently, no work will be done in moving +1 charge inside the conductor. But

work done in moving +1 charge from one point to another
=(intensity of electric field) × (distance between these points)

Since the distance between no two points can be zero, therefore the (intensity of) electric field inside a hollow conductor will be zero.

26. *Why is potential inside a hollow conductor same as on its outer surface ?*

Ans. Since the electric intensity inside a hollow conductor is *zero*, therefore there are no electric lines of force inside the conductor. Consequently, if a charge is moved about inside the conductor, no work will be done. But no work is done in moving a charge from place to place if it is an equipotential space. Thus the potential inside is the same as on the outer surface of the conductor.

27. *Any charged body connected to earth loses its complete charge to the earth. Then how can the leaves of an electroscope be made to diverge even when they are connected to the earth ?*

Ans. The real cause of the divergence of leaves is the presence of a P.D. between the leaves and the tin-foils of an electroscope, and not the repulsion between the similarly charged leaves. On insulating the electroscope and earthing its leaves, the leaves will be at zero potential. In order to create the requisite P.D., touch a +vely charged body to the tin-foils. The leaves will be found to diverge.

[**Note** that the charge on the leaves is not the decisive factor.]

28. *How can you have a positively charged body at zero potential ?*

Ans. Take a charged (say +vely) conductor *A* and connect it to the disc of a G.L. Electroscope. The conductor and the leaves are both at the same +ve potential. Bring a strong −vely charged body B, gradually near A. It produces an increasing −ve potential on A, thereby reducing A's own (free) +ve potential and you will notice a gradual decrease in the divergence of gold leaves. For a certain position of B, the leaves will collapse completely, indicating that the +vely charged body A is now at zero potential [The tin-foils of G.L.E. are kept earthed throughout the experiment].

29. *How can you have a positively charged body at negative potential* ?

Ans. First write the answer of Q. 28 given above.

Now take the body B still closer to A. Evidently the −ve potential produced on A by B becomes greater than the free +ve potential of A so that the resultant potential of +vely charged body A becomes negative. The leaves once again will show divergence which increases as B is brought nearer and nearer to A.

30. *Why does loss of energy take place when two or more charged conductors at different potentials are brought in contact* ?

Ans. When two or more conductors at different potentials are brought in contact, there will be a flow of charge from higher potential to lower potential conductor. This flow of charge causes sparking, accompanied by some sound, at the point of contact.

If the conductors are connected together by a conducting wire, the charge will flow through this wire. Since the flow of charge constitutes an electric current which is opposed by the resistance of the wire, a part of the electrical energy changes into heat and the connecting wire gets heated.

Thus a part of electrical energy is lost which reappears in the form of heat, light and sound energies.

31. *A Leyden jar when placed on an insulator, cannot be charged strongly. Why is it so* ?

Ans. A Leyden jar is a parallel-plate condenser. We know that the capacity of a condenser can be increased by bringing an earth-connected conductor near it. Now if the Leyden jar is placed on an insulator, its outer coating will not be earthed As a result, the potential of its inner coating will not be lowered much and the Leyden jar will not be charged strongly.

32. *When a Leyden jar is discharged, we get successive sparks. Why* ?

Ans. We know that the seat of charge in a condenser is its dielectric which is always non-conducting. A Leyden jar is a parallel-plate condenser with glass as the dielectric. When it is charged, the molecules of the glass-dielectric are strained by the opposite charges present on the two coatings of the condenser. On account of attraction, these charges come to stay on the opposite sides of the glass-dielectric and some charge enters the dielectric also. The remaining charge produces the first discharge [called *primary discharge* which is quite strong] but whatever charge has entered the dielectric that cannot come out so quickly and therefore it lingers on the dielectric and slowly comes out [this charge left behind on the dielectric after the primary discharge is known as the *residual charge*]. It is on account of the residual charge that we get other discharges (known as *secondary discharges*) but of less and less strength.

33. *Why does electricity appear to take many seconds to pass through a long submarine cable, when it is known that it should travel the same distance in a fraction of a second ?*

Ans. It is because a submarine cable acts as a condenser—the ocean forming the outer coating, the wire the inner, and the insulation as the dielectric. Before any signal can be received, enough electricity must flow to charge the cable (condenser) which may take several seconds in very long cables.

34. *The plates of a flat capacitor (or condenser) are connected to a galvanometer. One of the plates is earthed. A positive charge is passed between the plates. What will be the reading of the galvanometer ?*

Ans. When a +ve charge is introduced into a capacitor C (Fig. 6-3), a −ve charge is induced on the inside faces of the capacitor plates and it remains there, while a +ve charge appears on the outside faces. The +ve charge on the earthed plate escapes into the earth. The +ve charge on the other plate also escapes into the earth, passing through the galvanometer G. So the galvanometer G will show a deflection. But when the −ve charge begins to escape from the capacitor, the −ve charge will begin to flow into the earth from the plates. The charge flowing from one of the plates will pass through G which will then show a *deflection in the opposite* direction.

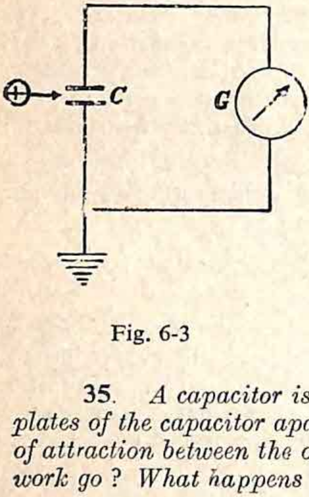


Fig. 6-3

35. *A capacitor is connected to an accumulator. If we move the plates of the capacitor apart, we do positive work to overcome the force of attraction between the oppositely charged plates. On what does this work go ? What happens to the energy of the capacitor ?*

Ans. For the capacitor's charge

$$Q=C.V=K.A.V/4\pi t$$

where C*, V, K, A and t have their usual meanings.

Since the plates of the capacitor are connected all the time to the accumulator terminals. the potential difference V applied to them remains constant. Therefore when t is increased, the charge Q must

---

*Practical unit of capacity or capacitance is **farad** while that of elastance (=reciprocal of capacitance) is **daraf**.

decrease. A partial discharge of the capacitor takes place and current flows in the circuit as a result of which the *accumulator is charged*.

Again, when t increases, C decreases ; but since V remains constant. the energy $(=\frac{1}{2}CV^2)$ of the capacitor also decreases. The energy which is thus released in the capacitor also goes on charging the accumulator. Thus all the work expanded on moving the plates apart goes on *increasing the accumulator's energy* and so too does a part of the energy stored in the capacitor.

36. *Why should electric charge leak through a sharp point ?*

Ans. The surface density of charge on a point situated on a charged surface is defined as the amount of charge present on a unit area surrounding the given point.

Considering a sphere of radius R and possessing a charge Q, its surface density of charge is given by :

$$\sigma = Q/4\pi R^2$$

Case (*i*) : If R is large (for a *flat surface*), σ is small ;

Case (*ii*) : If R is small (for a *sharp point*), σ is large.

Evidently, the distribution of charge cannot be uniform for any other conductor except the sphere (Fig. 6-4). Since more charge collects on a sharp point, the air particles, by conduction, will get more charge from a sharp point. Thus there will be more force of repulsion between similarly charged air particles and the charged point. As these air particles are repelled away, a partial vacuum is created. Naturally, fresh air-particles will rush to occupy this place and these too, after getting similar charge from the sharp point will be repelled away. This results in the generation of **electric wind** ensuing from the charged point. The leakage of charge through sharp points can thus be attributed to the electric wind.

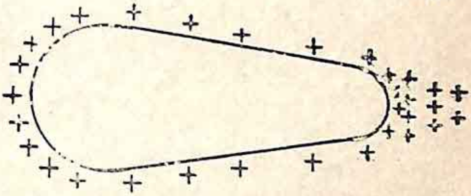


Fig. 6-4

37. *How can you demonstrate the leakage of charge through a sharp point ?*

Ans. (**i**) The straight flame of a candle, held in front of a sharp point attached to a charged spherical conductor, bends away from this point (Fig. 6-5).

(**ii**) Balance a light and conducting swastika mark on a pivot (Fig. 6-6). Connect it to a charging machine. As the charge starts leaking from its four sharp points, electric winds are created. The action of electric winds gives rise to an equal and opposite reaction. As a result the swastika mark starts revolving in the opposite direction of the electric wind. [This instrument is known as *Hamilton's Mill* or *Electric Whirl*].

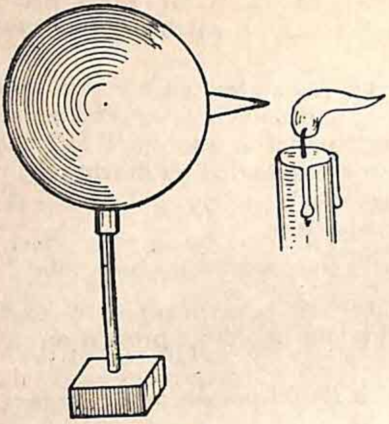


Fig. 6-5

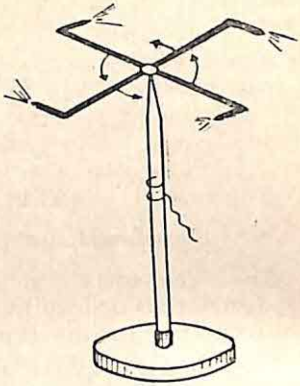


Fig. 6-6

38. (*a*) *Why does lightning usually strike high buildings or trees ?* (*b*) *And why is its path always zigzag ?*

Ans. (**a**) : It is because the lightning takes the easiest path between the cloud and the earth, and the resistance to its path offered by the tree or building is very considerably less than that offered by the same distance in air.

(**b**) : Its zigzag path can be attributed to the fact that the lightning flash (on account of its high temp.) compresses the air ahead of its path and making it more dense it interferes with its direct course.

[**Note** : *Forked lightning* is one which takes a zigzag path. *Sheet lightning* is the reflection from the clouds of forked lightning at a distance, usually over the horizon. In sheet lightning, the thunder is usually not audible.]

39. *Why do thunder storms usually follow a very dry spell of weather ?*

Ans. It is because dry air, being a non-conductor of electricity, will not easily permit the clouds to be relieved of their excess of electrical potential which accumulates till it is discharged as an electric storm.

40. *How does lightning occur ? Explain.*

Ans. In summer, the sun's heat sucks up water-vapour from the sea and land into the atmosphere. This water-vapour is often loaded with free electrons. Rain brings these electrons back to earth ; but sometimes there is no rain and currents of hot moisture-laden air are rising from the earth's surface and from the sea. When they reach cooler layers of the atmosphere, they form thunder clouds, at different heights. Some of the clouds carry very large loads of surplus electrons. Such clouds are often at the lower levels and will push any loose electrons at or near the earth's surface down to lower levels, leaving the earth's surface atoms short of electrons. Thus, an electric field is created between the earth and the thunder clouds. [Similarly an electric field is created between these clouds and others less heavily loaded with electrons]. As a result of electrons being pushed-and-pulled across an electric field, a flash of lightning passes between the earth and the cloud (or between two clouds).

41. *Why is it unsafe to take shelter under a tree or on damp ground during a thunder storm ?*

Ans. During a thunderstorm, the electric charge is always situated as close to the inductive influence—the cloud—as possible. It is therefore unsafe to be in the immediate vicinity of the area of the electric charge. A dry depression in the ground, where there are no trees or telephone poles, is the safest place to be during an electric storm. The objects (like tree) which reach nearest to the clouds are usually the most likely to be struck, and are therefore unsafe.

[**Note** : (*i*) Don't use your umbrella during a thunder storm, lest its rod becomes a lightning condutor.

(*ii*) A tall tree near a building is a very good protection for the building against lightning.]

42. *Why does a chimney made of bricks need a lightning conductor more than a steel chimney of the same height ?*

Ans. Material of bricks is non-conducting. It can, therefore, neither send an oppositely charged electric wind to neutralize the charge of the cloud, nor it can offer the path of least resistance to the electric discharge to pass down to the earth. On the other hand, steel is a very good conductor and hence the steel chimney acts as a lightning conductor itself.

[**Note** : For the same reason, the occupants of steel frame houses are not harmed by lightning.]

43. *What is the cause of the queer odour in the air after a thunder storm and in the vicinity of an electric discharge ?*

Ans. It is due to the chemical effect of the sparks by which the molecules of oxygen in the air are decomposed and rearranged in a modification known as **ozone**, which gas has the odd smell so noticeable.

44. *Is it true that the rain during a thunder storm is acidic ?*

Ans. *Yes.* Nitric acid is present because the lightning has the power of making a portion of the nitrogen and oxygen in the air to combine chemically which further combines with rain water, whereas previously they were but mechanically mixed.

45. *Why does a thunder storm often cause milk to turn sour ?*

Ans. It is because the electrical state of the air accelerates the work of the micro-organism (known as bacteria) in the milk, which in their growth convert the lactose (or sugar of milk) into lactic acid. This brings about coagulation or curdling of the milk by precipitation of the casein.

46. *There is a common saying that if you see the flash of lightning, you are safe. How far is this statement true ?*

Ans. Earth is always regarded at zero potential. When a man comes under a cloud where there has just been an electric discharge, he receives a shock due to the neutralization of the charge induced on his body and he is no more (*i.e.* dead). This shows that death occurs to him before he could see the flash of lightning. So the given statement is true.

47. *What is the cause of atmospheric electricity ?*

Ans. The exact cause of electrification of the atmosphere is not yet known. One explanation is that when evaporation takes place from the surface of water in the lakes, rivers and seas, the vapours going up are negatively charged, leaving the water +vely charged.

Another explanation is that the atmospheric electricity is due to the ultra-violet radiations of the sun, the cosmic rays and the radiations from radio-active substances.

48. *Why does the potential of the cloud rise very high ?*

Ans. When small charged droplets of water coalesce in the atmosphere, they form bigger drops and ultimately huge clouds. When $8(=2^3)$ droplets of water combine to form one drop, the charge on this drop becomes 8 times, its capacity becomes $2(=2^1)$ times and its potential 4 $(=2^2)$ times. When $27(=3^3)$ droplets combine, the capacity of the bigger drop becomes $3(=3^1)$ times but its potential becomes $9(=3^2)$ times. Thus we see that the potential rises very rapidly when droplets combine to form bigger drops Since millions of such drops combine to form a cloud, that is why a very high potential is developed on the cloud.

49. *Why is the compressed air used in the tank enveloping the charged sphere in Van de Graaff's Generator ?*

Ans. Air at the atmospheric pressure will cause the sparking between the highly charged sphere and the earth-connected metal tank—which will bring the sphere at zero potential. Compressed air (at 4 or 5 atmospheres) avoids the sparking and hence it necessitates its use.

50. *What are the advantages of a Van de Graaff's Generator over other electrical machines ?*

Ans. (1) It can produce a very high voltage, of the order of 10^7 volts.

(2) Better regulation is provided in it for its working with an electric motor.

(3) Very little charge is lost from its sphere or spheres by electric winds as its surface is very smooth and radius of curvature is very large.

51. *The earth is supposed to have about ½ million coulombs of negative electricity. How do we arrive at this figure ?*

Ans. It has been found that the potential at a point in the open air is always different from the potential of earth. It is always +ve and increases upward at about *1 volt per cm.* Since the potential increases upward, the charge on the earth must be negative.

Strength (F) of earth's electrostatic field is

$$F=\frac{\text{charge } Q}{(\text{radius } R \text{ of earth})^2}$$

Also $$F=\frac{\text{P.D.}}{\text{distance}}=1 \text{ volt/cm}=\frac{1}{300}\text{ e.s.u./cm.}$$

And $$R=6400 \text{ km.}=64\times10^7 \text{ cm.}$$

$\therefore$ $$Q=F.R^2=\frac{1}{300}(64\times10^7)^2 \text{ e.s.u.}$$

$$=\frac{(64\times10^7)^2}{300(3\times10^9)}=0{\cdot}455\times10^6 \text{ coulombs}$$

$$\simeq\tfrac{1}{2} \text{ million coulombs.}$$

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1. *Capacitance* is another name for capacity.
2. *Capacitor* is another name for condenser.
3. *Elastance* is the reciprocal of capacitance.

Part VII—Current-Electricity

Concise Current-Electricity

1. **Electric Current** : An electric current consists of a flow of electric charges called *electrons*. Its strength is measured by the rate of flow of charge. By convention, the current is regarded as passing in the opposite direction to the flow of electrons. The simplest device to get an electric current is a *cell*.

A **cell** is a contrivance by which electric energy is obtained due to the chemical actions taking place inside it.

Speed of current $= 3 \times 10^5$ km/sec.

Speed of an electron around the nucleus $= 160$ km./sec.

2. **Primary Cells** : These are the cells in which the first reaction gives the current (while in *secondary cells*, it is the second reaction which gives the current and the first reaction is utilised for storing the electric energy in them ; that is why these are also called *storage cells*, *accumulators* or simply batteries).

The simplest primary cell is a Voltaic cell, having maximum E.M.F. of 1·08 volts. This cell suffers from two main defects : (*i*) Local Action and (*ii*) Polarisation.

Local action is the eating away of its zinc plate caused by the presence of impurities in zinc. It is cured by rubbing the zinc plate with mercury – called *amalgamating* the zinc.

Polarisation is caused by the gradual deposition of H_2 bubbles on the copper (or + ve) plate – resulting in the gradual decrease in current-strength. It can be cured : (*i*) by not allowing H_2 bubbles to stick to the positive plate for which we remove them *mechanically by brushing* the plate after every 4 or 5 minutes or by making +ve plate rough and pointed (*e.g.* in Smee's cell), (*ii*) by not allowing H_2 bubbles to reach +ve plate at all either by *oxidising* H_2 to form water by passing them through a strong oxidising agent *e.g.*, MnO_2 for Lechlanche cell or by *replacing* H_2 by some metallic carrier by passing them through some chemical *e.g.* copper sulphate solution for Daniell cell.

3. **Effects of an Electric Current** : Since we cannot always risk our life by touching current-carrying conductor and getting a shock (called *physiological effect* of currents), there are several other effects of an electric current :

(*a*) Magnetic effect ; (*b*) Heating effect ; (*c*) Chemical effect ;

(*d*) Mechanical effect : Electric motors and fans are familiar examples of the mechanical effect of currents.

(*e*) Nervous effect : An electric discharge passing through living tissues produces a contraction in the muscles.

4 Magnetic Effect of an Electric Current : Whenever an electric current flows, it produces a magnetic field all around it. This effect helps us in knowing the presence as well as the direction of current in a wire by applying SNOW Rule or Ampere's Swimming Man Rule. The strength of this field is determined by the position in which it is measured and the size of the current flowing.

5. Magnetic Fields due to Currents : The plane of the magnetic field, produced by a current in a wire, is perpendicular to the plane of the current (Fig. 7-1) while the direction of the mag. field is given by Maxwell's Right-handed Corkscrew Rule : "Imagine a right-handed corkscrew being turned so that its axis or tip is moving in the direction of the current *C* ; then the direction of rotation of the right-hand thumb is the direction of the magnetic lines of force" (Fig. 7-2).

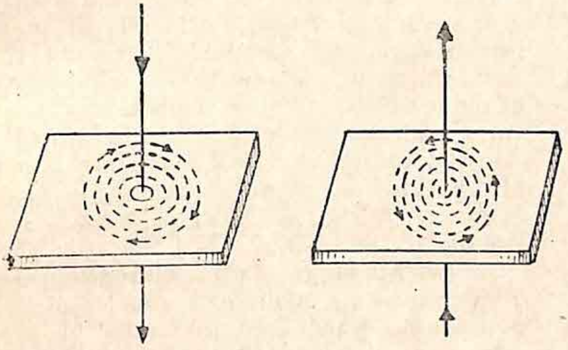


Fig. 7-1

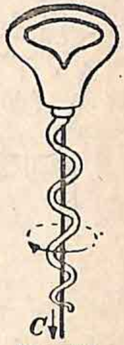


Fig. 7-2

6. Uses of the Magnetic Effect of an Electric Current :

(1) The absolute unit of electric current (the ab-ampere) is based upon the magnetic effect of a current. When a magnetic field of one oersted is produced at the centre of an arc 1 cm. long of a circle of 1 cm. radius by a current, this current is called the ab-ampere (or e.m.u. of current).

10 amperes =1 e.m.u. of current.

The e.m.u. of current is called **biot** which is that constant intensity which, when maintained in two parallel and infinitely long rectilinear conductors of negligible circular section, placed at a distance of 1 cm. apart in vacuum, would produce between those conductors a force of 2 dynes per cm. length.

(2) The Tangent Galvanometer uses the magnetic effect of an electric current to compare the field (*F*) produced by a current with

the earth's horizontal field (H). *It is therefore used in the laboratory for measuring current but not normally for standardisation* as H changes from place to place. It applies *Tangent Law* and the current passing through it is proportional to the tangent of the angle of deflection θ *i.e.*, $C \propto \tan\theta$.

(3) The magnetic effect produced by a current flowing in a coil of wire wound round an iron core is the basic principle of all apparatus using electro-magnets, *e.g.* electric bell, telegraph, relay, etc.

7. Force on a current-carrying conductor held in a magnetic field : When a wire carrying current is held in a magnetic field, a force acts on it. The magnitude of this force depends upon the strengths of the current and the field. If the current and the field are at right angles, the direction of the force is given by Fleming's Left-hand Rule *i.e.* if the thumb, first finger and middle finger of the left-hand are held mutually perpendicular, with the *first* finger in the direction of the *field* and the middle finger in the direction of the *current*, then the thumb gives the direction of motion of the current-carrying conductor (Fig. 7-3).

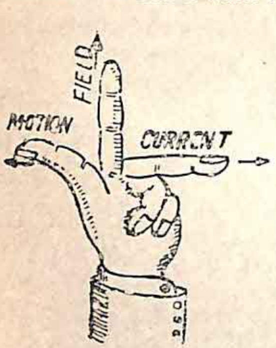


Fig. 7-3

(a) Moving Coil Galvanometer : This consists essentially of a small coil A of fine wire wound on an insulating frame and suspended by a fine wire F of phosphor-bronze so that it can rotate between the poles (N,S) of a powerful magnet (Fig. 7-4). The coil rotates round a

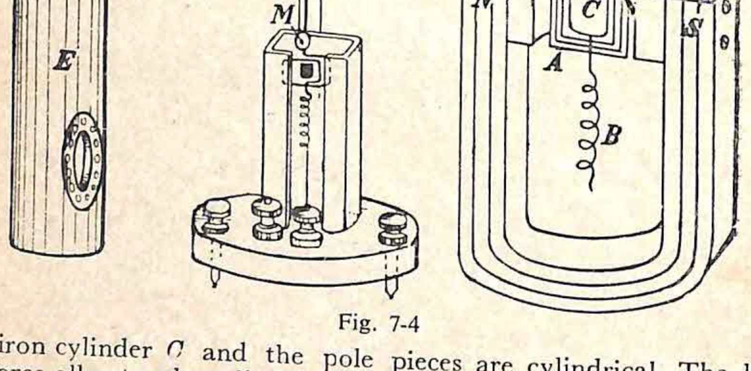


Fig. 7-4

soft-iron cylinder C and the pole pieces are cylindrical. The lines of force all enter the cylinder at right angles to its curved surface, and the force on the coil is always in a direction perpendicular to the current's direction and the field. The forces ($H.C.l$ and $H.C.l$) caused by the passage of the current constitute a couple which is opposed by the torsion produced in the suspension wire, so that the deflection of the coil (measured by an optical lever and a plane mirror (M) is proportional to the current passing, and the coil returns to the same position when the current is cut off. The forces ($H.C.l$ and $H.C.l$) always act at right angles to the field and the current (Fig 7-5). The field is made radial by using cylindrical pole-pieces (N,S) and a soft-iron cylinder or core (Fig. 7-6).

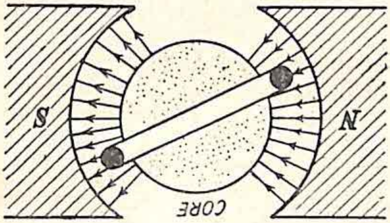
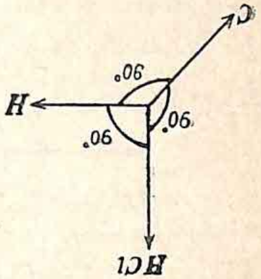


Fig. 7-5



Fig, 7-6

(**b**) **Electric Motor** : The main features of a simple electric motor (Fig. 7-7) are :

(*i*) A powerful magnet NS, which, in small motors, is usully a permanent one, but always an electro-magnet in large motors.

(*ii*) A coil, $CDEF$, of wire which can rotate about an axis perpendicular to the magnetic field H.

(*iii*) A commutator, GG, to which the ends of the coil are joined and through which the direction of the curruent through the coil can be reversed every 180° of rotation.

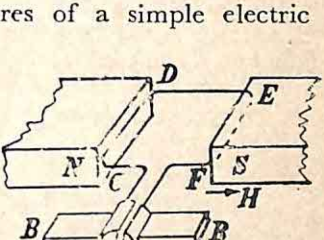


Fig. 7-7

In the Fig. (7 7), the left-hand conductor B carries the current into the plane of the paper and the right-hand conductor B carries current out of the plane of the paper. By Fleming's Left-hand Rule, the force on the right-hand side of the coil is vertically up and on left-hand side vertically down. These forces constitute a couple which causes the coil to rotate in anti-clockwise direction. The momentum of the coil carries it past vertical and the current through CD and EF is therefore reversed by the commutator GG. The rotation of the coil therefore continues in the *same direction*.

8. Ohm's Law : George Siemons Ohm in 1826 stated that : provided the physical conditions (temp. etc.) remain constant, the current (say C) in any conductor is proportional to the potential differenee (say V) between its ends. Thus

$$C \propto V \qquad \text{or } C=\left(\frac{1}{R}\right)V \qquad \text{or } \frac{V}{C}=R$$

where $1/R$ is called electrical conductance and R is called electrical resistance of the conductor. Unit of resistance is *ohm* while that of conductance is *mho*.

9. Applications of Ohm's Law :

(*i*) **Resistances in series** : If the same current (say C) flows through two or more resistances (say $r_1, r_2, r_3, \ldots$), they are said to be connected in series (Fig. 7-8). Then their effective or equivalent resistance (say R) is equal to the sum of these individual resistances. Thus :

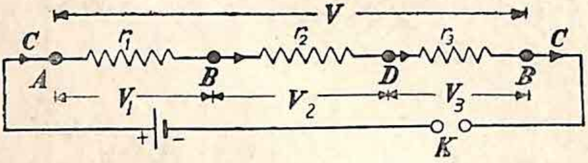


Fig. 7-8

$$R=r_1+r_2+r_3+\ldots$$

(*ii*) **Resistances in parallel** : If at some point in a circuit a current divides between a number of branches which later on reunite, then these branches (of resistances $r_1, r_2, r_3, \ldots$) are said to be connected in parallel (Fig. 7-9). Then the reciprocal of their equivalent resistance (R) is equal to the sum of the reciprocals of their individual resistances. Thus

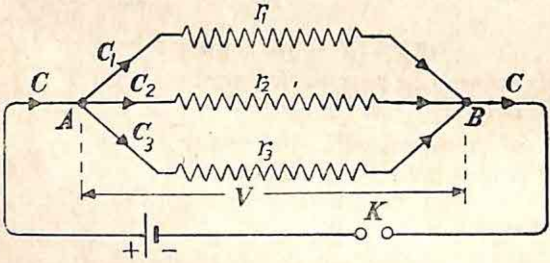


Fig. 7-9

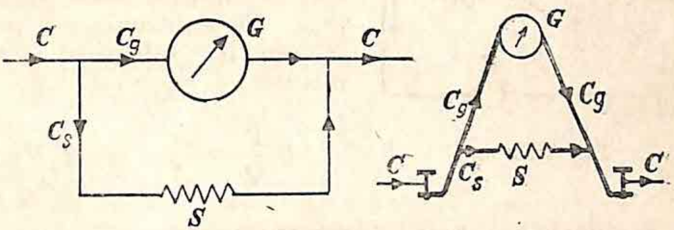
$$\frac{1}{R}=\frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3}+\ldots$$

and R will be less than each individual resistance.

(*iii*) **Conversion of a Galvanometer into an Ammeter** : Let the resistance of the galv. be G ohms and the current required for full scale deflection be C_g ampere (Fig. 7-10-*a*). If the galv. is to be converted into an ammeter to read upto C amperes, then the value of the *shunt* resistance S required for *parallel* connection can be calculated from the relation :

$$C_g = \frac{S}{S+G} \times C \quad \text{or} \quad S = \frac{C_g}{C-C_g} \times G$$

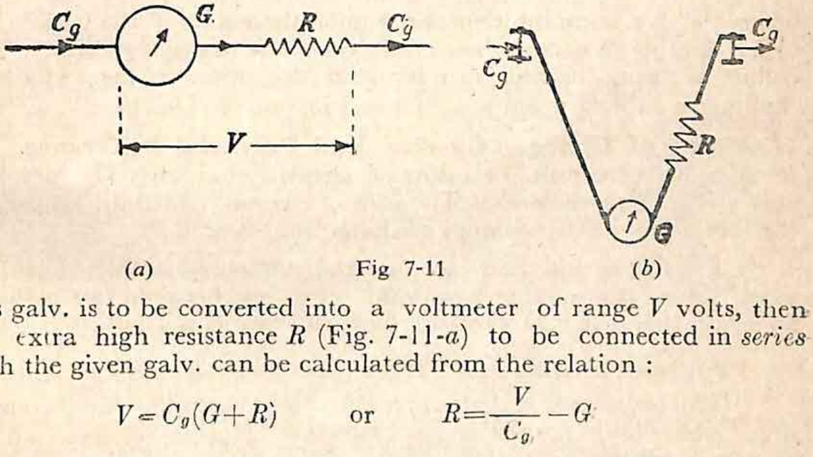
Actually $(C-C_g) = C_s$ which is the current passing through the shunt. Also C_g is the maximum admissible current for the galv. and is equal to the product of its sensitiveness and number of divisions on its scale. Letter **'A'** in Fig. (7-10-*b*) is the first letter of **Ammeter** and represents the principle of its conversion.



(*a*) Fig. 7-10 (*b*)

Since the effective resistance of an ammeter is very low, *it is joined in series* in the circuit so that its inclusion in or exclusion from the circuit does not change the main current in the circuit.

(*iv*) **Conversion of a Galvanometer into a Voltmeter :** Here G and C_g represent the same quantities as in (*iii*) above. If this galv. is to be converted into a voltmeter of range V volts, then the extra high resistance R (Fig. 7-11-*a*) to be connected in *series* with the given galv. can be calculated from the relation :



(*a*) Fig 7-11 (*b*)

$$V = C_g(G+R) \quad \text{or} \quad R = \frac{V}{C_g} - G$$

Letter "**V**" in (Fig. 7-11-*b*) is the first letter of **Voltmeter** and represents the principle of its conversion.

Since the effective resistance of a voltmeter is very high, it is *joined in parallel* across the points in the circuit whose P.D. is required to be measured so that the main current in the circuit does not change.

(*v*) **Wheatstone Bridge Circuit** : It is an arrangement of four resistances, a cell and a galv. G (Fig. 7-12) balanced in such a way (either by changing the resistance R or by changing the ratio of P and Q resistances) that the points B and D attain the same potential. The galv. G will then show zero deflection. Then the unknown resistance X can be calculated from the relation :

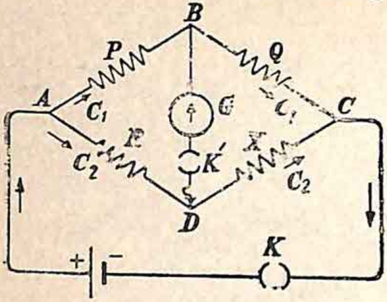


Fig. 7-12

$$\frac{P}{Q}=\frac{R}{X} \quad \text{or} \quad P.X=Q.R$$

The chief Wheatstone Bridge circuits are :

(*i*) Metre Bridge : (*ii*) Post Office Box.

10. Resistance of a Uniform Wire : The resistance R of a uniform wire is directly proportional to its length l, inversely proportional to its cross-sectional area a and depends upon the material of which it is made.

$$\therefore \qquad R \propto l\,; \qquad R \propto \frac{1}{a}$$

$$\text{or} \qquad R \propto \frac{l}{a}\,; \qquad \therefore\ R=\frac{s.l}{a}$$

where "s" is a constant, depending upon the nature of the wire. It is called *Specific Resistance* (or resistivity) of the material of wire. It is defined as being the resistance between the opposite faces of a solid centimetre cube of given material and its unit is *ohm-cm.*

11. Units of Charge, Current and Potential Difference : An electric current consists of a flow of electric charges. The practical unit of charge is *coulomb*. The unit of current, called the ampere, is the rate of flow of 1 coulomb of charge per second.

The *volt* is the unit of potential difference. When 1 joule of work is done in moving 1 coulomb of charge between two points in a circuit, then the P.D. between these two points is 1 volt.

For practical and legal purposes, the definitions are as follow :

(*i*) The *ampere* is that current which when flowing through a silver voltameter (containing a standard solution of silver nitrate) liberates 0·0011183 gm. of silver in one second.

(*ii*) The *volt* is $\frac{1}{1\cdot0183}$ of the P.D. between the terminals of a Weston Cell on open circuit at 20°C.

(*iii*) The International *ohm* is the resistance of a column of mercury of 1 sq. mm. cross-section and 106·3 cm. long at 0°C.

12. Internal Resistance (of a Cell) : Every thing which conducts electricity has resistance although this may be so small in many cases as to be ignored. Batteries and cells have resistance (on account of their electrolytes, size of plates and the distance between the plates) which is often not constant and depends upon their age and use they have had. This resistance is called their *internal resistance.* A well-charged accumulator has an internal resistance of less than 0·01 ohm while that of a used torch-cell can be as high as 100 ohms.

13. Grouping of Cells :

(a) Cells in Series (Fig. 7-13) : This arrangement gives *maximum P.D* across the terminals of the external resistance but the current due to n cells in series will be n times the current due to one cell (in the same external resistance) only when external resistance (R) is far greater than the internal resistance (r) of these cells.

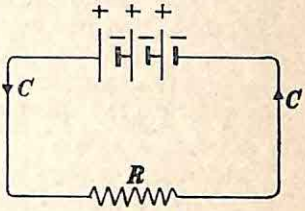


Fig. 7-13

(b) Cells in Parallel (Fig. 7-14) : This grouping gives *minimum P.D.* (=that due to one cell) across the external resistance R but the current due to n cells will be n times the current due to one cell only when internal resistance r of each cell is far greater than the external resistance R of the circuit.

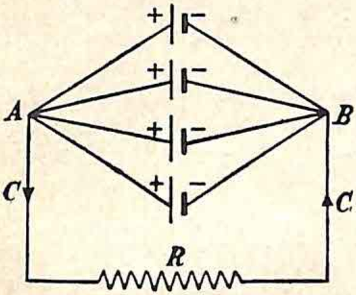


Fig. 7-14

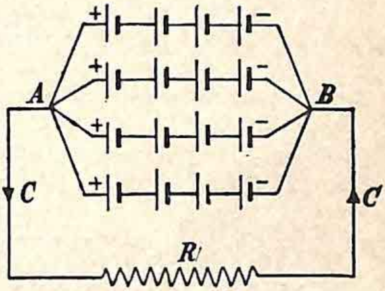


Fig. 7-15

(c) Cells in Mixed Grouping (Fig. 7-15) : This arrangement is used only when neither $R > r$ nor $r > R$. And to obtain maximum current in the external resistance, we must have

$$\frac{r}{R} = \frac{\text{no. of rows (say } m\text{) in parallel}}{\text{no. of cells (say } n\text{) in each row}}$$

or **R = total internal resistance**

14. Potentiometer : All ordinary voltmeters require some current to operate them. Because of internal resistance of the cell, a voltmeter never indicates true E.M.F.* of a cell, although a good voltmeter takes a very small current and the error is small. This error will become zero if the voltmeter has an infinite resistance, but then this voltmeter will stop recording any reading. This difficulty can be removed by using a potentiometer which compares E.M.F.s without taking any current. But remember that :

---

*E.M.F. of a cell is defined as numerically equal to the work done by the cell per second in maintaining a unit current.

(*i*) All the positive poles of various cells are connected to one terminal ;

(*ii*) E.M.F. of the accumulator must be more than that of each of two cells to be compared.

15 Work Done in an Electrical Circuit : If a charge of Q coulombs flows in t seconds in a conductor maintained at a potential difference of V volts and as a result a current of C amperes is developed in the conductor of resistance R ohms, then the work done or electrical energy spent is given by :

$$W=Q.V=C.V.t=C^2.R.t \text{ joules}$$

Also $$\text{Power}=\frac{W}{t}=C.V \text{ joules/sec.}$$

$$\therefore \quad \textbf{Watts}=(\textbf{Amperes})\times(\textbf{Volts})$$

$$1 \text{ Watt}\times\text{hour}=3600 \text{ joules}$$

and $$1 \text{ Kilo-watt}\times\text{hour}=3600\times1000 \text{ joules.}$$

K.W.H. (Kilo-watt × hour) unit or *B.T.U.* (Board of Trade Unit) is that unit in which electrical energy is bought and sold. Thus

$$\text{No. of K.W.H. units}=\frac{\text{watts}\times\text{hours}}{1000}=\frac{\text{amperes}\times\text{volts}\times\text{hours}}{1000}$$

16. Heating Effect of an Electric Current : Assuming the quantities as given in Art. 15 above, let H calories be the amount of heat produced due to conversion of electrical energy. Remembering that $J=4{\cdot}2\times10^7$ ergs/calorie$=4{\cdot}2$ joules per calorie, we get

$$H=\frac{C.V.t}{4{\cdot}2} \text{ calories}$$

$$=\frac{C^2.R.t}{4{\cdot}2} \text{ calories}$$

This last relation states **Joule's Law** mathematically ($H\propto C^2$; $H \propto R$; $H \propto t$) and there are lots of electrical instruments based on heating effect of currents.

17. Chemical Effect of an Electric Current : It is also called electrolysis which is the splitting-up of a material (usually in solution) into ions by the passage of an electric current through it. This is done in an *electrolytic cell* or a *voltameter*. In the cell is the *electrolyte* which immediately breaks up into ions. *The more dilute is the electrolyte, the greater is* the *number of free ions in the electrolyte*. The current enters and leaves the voltameter by the *electrodes*—the one by which it enters is called the *anode* and the other by which it leaves is called the *cathode*.

It is at the cathode that H_2 and metal ions are deposited.

18. Faraday's Laws of Electrolysis :

(*i*) The amount of an ion deposited on an electrode is proportional to the quantity of charge (Q) passing, *i.e.* the product of current (C) and time (t).

(*ii*) The mass (W) of an ion deposited is proportional to its chemical equivalent.

Thus $W \propto C.t$ or $W = Z.C.t$

where Z is a constant called the electro-chemical equivalent (E.C.E.) of the element. It is defined as the mass of the element deposited when 1 coulomb charge (or 1 ampere current for 1 second) flows through its solution "Z" varies from element to element and is proportional to the chemical equivalent.

19. Applications of Electrolysis : Accumulators, purification of metals, electroplating*, electrotyping, verification of accuracy of ammeters, determination of reduction factor of a Tangent Galvanometer, determination of chemical equivalent or atomic weight of an element are some of the important applications of electrolysis.

The processes of charging and discharging of an accumulator are accompanied by a change in the concentration of its electrolyte—on discharging, the specific gravity decreases and on charging it increases.

20. Faraday's Laws of Electro-magnetic Induction :

(*i*) *As long as* there is a *change* in the number of magnetic lines of force passing through a *closed* coil or circuit, an induced current or E.M.F. is set up in the coil.

Whenever there is an *increase* in the magnetic lines of force, an *inverse* current is set up and for a *decrease* in the magnetic lines of force a *direct* current is set up in the closed coil.

(*ii*) The strength of the induced current or E.M.F. is directly proportional to the *rate of change* in the number of magnetic lines of force traversing the closed coil.

21. Direction of Induced Current or E.M.F. : There are 3 ways of knowing the direction of the induced current or E.M.F. set up in a closed coil on account of electro-magnetic induction :

(*i*) **Faraday's way :**

Increase—**I**nverse ; **D**ecrease—**D**irect.

(*ii*) **Lenz's way** : The direction of induced current or E.M.F. is such that it opposes the same agency which gave birth to it. This is known as *Lenz's Law*.

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*Immediately after electroplating, the article is thoroughly washed with distilled water so that the fresh deposit is not oxidised.

The deposit will be spongy and brittle if we use a strong current.

The deposit will not be uniform but will be spotted if we use unsteady current.

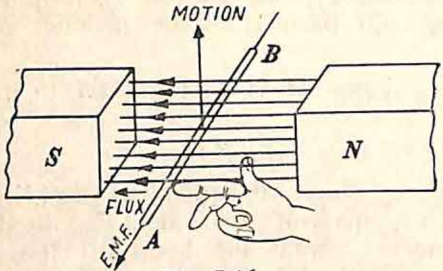

Fig. 7-16

(*iii*) **Fleming's way** : If the thumb, first finger and middle finger of the right hand are held mutually perpendicular, with the first finger in the direction of the magnetic field (or flux) and the thumb in the direction of motion of the closed coil, then the middle finger points in the direction of the induced current or E.M.F. (Fig. 7-16). This is known a **Fleming's Right-hand Rule.**

22. Eddy Currents : By Faraday's Law, an E.M.F. is generated whenever the number of magnetic lines of force through a circuit changes. If a piece of metal is placed in a variable magnetic field, an E.M F. will be set up between different parts of the metal piece. Since the metal is a good conductor, currents will flow between its various parts. Currents of this type are called eddy currents.

23. Applications of Electro-magnetic Induction :

(*i*) **Induction coil** : Its purpose is to produce a strong *unidirectional* current from a low D.C source. It is achieved by using (*a*) a primary coil of relatively less turns of thick copper wire, (*b*) a secondary coil of many (several thousands) turns of fine copper wire, and (*c*) automatic make and break mechanism in the circuit of the primary coil. A condenser is also included across the contacts of the make and break arrangement. Its (condenser's) purpose is to avoid sparking and speed up the break action.

(*ii*) **Transformers** : The purpose of a transformer is to provide *from an A.C. source* a voltage which is either greater or less than that of the source. When voltage increases, the current decreases and *vice versa* because wattage of the source is constant (and watts = amperes × volts).

$$\frac{\text{No. of turns of Primary Coil}}{\text{No. of turns of Secondary Coil}}=\frac{\text{Primary E.M.F.}}{\text{Secondary E.M.F.}}$$
$$=\frac{\text{Secondary Current}}{\text{Primary Current}}$$

In a *step-up* transformer, voltage in the secondary coil is higher than that in the primary coil which is made of thick wire while the secondary coil is of thin wire. The opposite is true for a *step-down* transformer.

(*iii*) **Telephone** : It is a device to transmit sound to a distance with the help of electricity (Tele ..... afar, phone .....sound). The instrument was first invented by *Alexander Graham Bell* (1875). Modern telephone is a modified form of Bell's instrument. The sound waves are made to strike against a diaphragm to set it into vibration. It is in immediate contact with carbon particles which are also set into vibration. A battery sends current through these carbon granules, in the telephone line. With the variation in the compression of granules, the strength of the current is altered. At the distant end, the electric energy is converted back into sound vibrations by the receiver.

(*iv*) **Dynamo** : A dynamo or generator is a machine used to convert mechanical energy into electrical energy (A *reversed dynamo* is also called *motor* which converts electrical energy into mechanical energy). The fact that an E M.F. is induced in a conductor or a closed coil when it cuts magnetic lines of force is the basis of the dynamo. But the direction of this induced E.M.F. or current changes after its every half revolution. Hence initially a dynamo generates A.C (*i.e.* Alternating Current) which is transmitted from the dynamo with the help of two *separate rings*. A.C. can be converted into D.C. with the help of a simple device called *commutator* or *split-ring method.*

The strength of an A.C. changes all the time between a maximum and a minimum value. Its net effect is indicated in terms of its R.M.S. (Root Mean Square) values. For a 230-volt supply, the maximum or peak voltage is $230\sqrt{2}=325$ volts.

The ordinary house-supply-currents at 200—250 volts rarely cause fatal accidents because the resistance of the body is quite large so that very little current passes through it. If however, the body is well "earthed", these voltages will prove fatal.

The ratio of the true watts to the apparent watts developed in a component of a circuit through which an A.C. is passing is called **power factor.** It is equal to the cosine of the phase angle.

24. Electronics : It is the science that deals with the use of electrons emitted from solids or liquids and made to move through vacuum or a gas.

The radio, T.V., Radar, electron-microscope, betatron, cyclotron, X-ray machine, sound-film recording and reproducing apparatus, the electronic brain (*i.e.* computors), automatic traffic control, etc. are all electronic devices.

The lights of neon signs, sodium vapours and mercury vapours, and flourescent lamps are all produced by high speed electrons dashing through a gas.

25. Transistor : It was invented by two American scientists : *Bardeen Brattain* and *Shockley* in 1948. This device consists of a piece of semi-conducting solid like germinium or silicon to which contact is made at appropriate places by three wires. The parts resemble in function the cathode, anode and grid of a thermionic (or triode) valve. Transistor can perform many of the operations for which valves have been used in radio and television. The use of transistor valves has helped to reduce the size of the radio and T.V.

sets considerably and thus they have been made more handy and easily portable.

26. Television : It was invented by *John L. Baird*. Television is a process of transmitting and receiving visual images electrically. The process of communication consists of changing light rays into electrical waves, radiating them into space and receiving them on the apparatus as visible light rays. The image to be transmitted is divided into thousand of light spots which trace a number of parallel horizontal lines across the viewing screen. As its spot moves along each line, its brightness is changed, so it recreates the lights and shadows along each line. When the image has been fully covered, the light spot returns to the starting point and traces out another picture. The pictures move in succession like the frames of a motion picture, reproducing the image. In this way, a complete picture is made out in $\frac{1}{30}$th of a second. There are 525 scanning lines from the beginning of one picture to the beginning of the next. Usually television waves cannot be seen beyond 120 to 160 km. In U.S.A. and U.S.S.R., however, T.V. broadcasts are seen throughout the country by the use of coaxial cables and now with the help of satellites.

27. Radar : The word "RADAR" is an abbreviation of **Ra**dio **D**etection **A**nd **R**anging, the original and still principal application of the instrument. The name is applied to both the technique and the equipment used.

Detection of an object with radar is achieved by transmitting radio waves of very short wavelengths into the atmosphere. When an object enters into the transmitting beam, it reflects back some of the waves which are received by the instrument. The distance of the object is calculated from the time taken by the radio waves to strike the object, get reflected and to reach the transmitter. The actual indicator usually takes the form of one or more *cathode ray tubes* which act as radar screen. From the variations in the pattern of light appearing on the radar screen, the direction (and often the size) of the object intervening the radio beam can be estimated.

During Second World War, radar was employed by aeroplanes and by ships for locating enemy ships. In peace time, it has been used in controlling of aircrafts approaching and leaving airports, in ground and air surveying and for meteorological purposes.

Objective Type Questions

CHAPTER XL

PRIMARY CELLS

I. Complete the following statements with suitable words or phrases :

(1) A Leclanche cell gives...... current whereas a Daniell cell gives......current.

(2) In the Leclanche cell, ...is used as depolariser.

(3) The depolariser used in the Daniell cell is......

(4) The electrolyte in the Leclanche cell is......and in the storage cell is......

(5) A battery is a group of......

(6) Bunsen cell has the......E.M.F. and the voltaic cell has the ......E.M.F.

(7) In the secondary cell,...... energy is first converted into...... energy and then......energy is converted back into......energy.

(8) The E.M.F. of the lead accumulator is......when fully charged and......when discharged.

(9) Cells are connected in......when the internal resistance is very large and in......when the external resistance is very large.

(10) A voltaic cell consists of......and......plates immersed in ......

II. Select the appropriate completions from the clues provided against each statement :

(1) ......is stored by the storage cell.
[Electric current, Electrical energy, Chemical energy]

(2) For electric bells,......cell is used and for telegraph work, ...cell is used. [Leclanche, Daniell, Bunsen]

(3) A storage cell has a......internal resistance. [zero, low, high]

(4) The Dry cell is actually a......cell and it works as long as its contents are...... [Daniell ; Leclanche ; dry ; wet]

(5) The E.M.F.s of Leclanche cell, Daniell cell, Voltaic cell, lead accumulator and Bunsen cell are respectively......volts.
[1·1 ; 1·08 ; 1·5 ; 1·90 ; 2·2]

(6) E.M.F. of a cell is ......than its potential difference. [smaller, greater]

(7) Polarisation is removed by the mechanical method in...... cell. [Daniell's, Bunsen's, Smee's]

(8) The zinc and carbon in a dry cell are...... [electrolytes ; electrodes ; electric generators]

(9) In a voltaic cell, the reaction between pure zinc and H_2SO_4 starts only when *Cu* and *Zn* rods are connected externally because......

(*a*) it releases electrons to maintain the current.

(*b*) it helps in keeping the two rods at different contact potentials.

III. Pick out the correct statements :

(1) Polarization is due to the presence of hydrogen on +ve plate produced by the action of sulphuric acid on zinc in the cell.

(2) Local action is due to the presence of impurities in the commercial zinc and is removed by amalgamating the zinc rod.

(3) In Bunsen's cell, polarisation is removed by chemical method, and in Daniell's cell it is removed by electro-chemical method.

(4) A dry cell is actually a dry one.

(5) Strong current is produced by a cell.

(6) In a cell, chemical energy is converted into electrical energy.

(7) A battery hydrometer is used to find the charged or discharged state of a lead accumulator.

(8) On charging a lead accumulator, the sp. gravity of H_2SO_4 is raised and on discharging it is lowered.

IV. Which are Primary, Secondary and Standard Cells ? Select from the following :

(1) Leclanche cell ; (2) Daniell cell ; (3) Bunsen cell ;
(4) Volta's pile ; (5) Grove cell ; (6) Torch-battery ;
(7) Nife-cell ; (8) Weston-cadmium cell ;
(9) Motor-car batteries : (10) Chromic acid Cells.

CHAPTER XLI

GALVANOMETERS

I. Completion Test :

(1) Magnetic effect of an electric current was discovered by......

(2) Magnetic lines of force round a st. wire carrying an electric current are ...... in shape.

(3) In a Tangent Galvanometer, ... $\propto$ ......

(4) Current $C = \frac{\dots \times \dots}{\dots\dots\dots} \times \tan\theta$ for a Tangent Galv.

(5) For measuring currents, the Tangent Galv. coil must be set with the plane of the coil......

(6) ......of the laminated magnet is required in the Moving Coil Galv.

(7) Tangent Galv. is also called......

(8) 1 e.m.u. of current=......amperes.

(9) A voltmeter has a... ..resistance and an ammeter has a...... resistance.

(10) A voltmeter is joined in......and an ammeter is joined in...... with the rest of the circuit.

(11) The range of a galv. can be......by the use of a shunt.

(12) Two long parallel wires carrying currents in the same direction will......each other.

(13) The law of like parallel currents can be demonstrated with the vibrating spiral experiment of......

(14) Fleming's Left-hand Rule can be demonstrated with the help of......

II. Selection Test :

(1) For converting a Moving Coil Galvanometer into an ammeter, a......resistance is employed in......to it.
[high, low, parallel, series]

(2) For converting a Moving Coil Galvanometer in a voltmeter, a ......resistance is employed in......to it.
[high, low, parallel, series]

(3) The magnetic intensity due to current-carrying coil acts ......to the plane of the coil. [parallel, perpendicular]

(4) If the current is flowing in the clockwise direction, when looking upon the end of a coil of a wire, that end will be a......pole.
[north, south, neutral]

(5) The plane of magnetic lines of force surrounding the straight wire, carrying an electric current, at any point is......to the plane of the current. [parallel, prependicular]

(6) In Fleming's Left-hand Rule, first finger represents......, central finger represents......, and thumb represents......
[current, field, motion of the conductor]

(7) Magnetic field is not associated with......

(*a*) a charge in uniform motion. (*b*) an accelerated charge.
(*c*) a decelerated charge. (*d*) a stationary charge.

(8) The electric charge sitting on an electroscope produces in the surrounding space.......

(*a*) electric field only. (*b*) magnetic field only.
(*c*) both electric and magnetic fields.
(*d*) neither electric field nor magnetic field.

(9) A charged particle moves through a magnetic field. The effect of the field is to change the particle's......

(*a*) direction of motion, (*b*) mass, (*c*) speed, (*d*) energy.

(10) It is possible to measure the passage of 50 electrons per second with a certain sensitive device. This corresponds to a current of approximately......

(*a*) $8{\cdot}0\times10^{-18}$ ampere. (*b*) $1{\cdot}6\times10^{-20}$ ampere.
(*c*) $8{\cdot}0\times10^{-20}$ ampere. (*d*) $1{\cdot}6\times10^{-19}$ ampere.

(11) Sensitiveness of a Tangent Galvanometer increases by......

(*a*) using a long and heavy pointer.
(*b*) decreasing the controlling magnetic field.
(*c*) decreasing the number of turns in the coil.
(*d*) increasing the radius of its coil.
(*e*) increasing its reduction factor.

(12) Sensitiveness of a M.C. Galvanometer increases by......

(*a*) decreasing the number of turns in the coil.
(*b*) decreasing the area of the coil.
(*c*) increasing the controlling magnetic field.
(*d*) increasing its reduction factor.
(*e*) increasing the temp. of the laboratory.

(13) The magnetic field of the earth is approximately 0·3 gauss. The strength of the magnetic field in a M.C. Galvanometer is......

(*a*) $<0{\cdot}3$ gauss. (*b*) $=0{\cdot}3$ gauss. (*c*) $>0{\cdot}3$ gauss.
(*d*) much larger than 0·3 gauss.

(14) A M.C. Galvanometer shows a deflection because of......

(*a*) action between current and magnetic field.
(*b*) action between currents in different parts of the coil.
(*c*) electro-magnetic induction.

III. Choose the correct statements :

(1) A magnetic field does not always produce a force on a moving electron.

(2) Shunt is used for protecting a sensitive galv.

(3) $F=\dfrac{2\pi\, n.C}{10.r}$ is the strength of magnetic field at the centre of a coil carrying C amperes of current.

(4) $C_g=\dfrac{S}{S+G}\times C$ gives the strength of current passing through a shunted galv.

(5) $K=\frac{H\,.\,r}{2\pi\,n}$ e.m.u. of current is the reduction factor of a Tangent Galv.

(6) Due to a straight conductor carrying current, the magnetic lines of force are circular all around the conductor and the plane of the current is at right angles to that of the magnetic lines of force.

(7) By increasing (*a*) the number of turns of wire and (*b*) the area A, the sensitiveness of a M.C. Galv. can be increased.

(8) If a conductor carrying current is placed in a magnetic field due to a fixed magnet, the motion of the conductor is given by Fleming's Left-hand Rule.

(9) Oersted discovered the magnetic effect of an electric current.

(10) In a M.C. Galv., a radial field is obtained by fixing a soft iron core in-between the concave poles of its magnet.

CHAPTER XLII

OHM'S LAW AND RESISTANCE

I. Completion Test :

(1) When $V=1$ volt, and $R=1$ ohm, then under Ohm's Law, $C=$......

(2) ......is the resistance offered by one cm. solid cube of the material of the wire.

(3) ...... is a unit of a resistance, ... is a unit of specific resistance and ...... is a unit of electric conductance.

(4) In an electrical circuit, ... is generally used to vary its resistance.

(5) E.M.F. of a cell=its P.D. in a/an ......

(6) In a resistance box, different resistances are connected in ......

(7) Resistance ...... with the increase in the temp. of a semi-conductor.

(8) Resistance ...... with the increase in the temp. of a conductor.

(9) E.M.F. of two cells can be very accurately compared with the help of a/an......

(10) Arms P and Q are called ...... of a Wheatstone Bridge.

(11) Metre Bridge gives ...... accurate result than P.O. Box.

II. Selection Test :

(1) Resistance ...... the flow of charge.

[opposes, increases, decreases]

(2) A perfect conductor has ...... resistance, while a perfect insulator has......resistance. [small, infinite, zero]

(3) Metals have high conductivity because they have......

(*a*) a solid crystalline structure.
(*b*) electrically positive iron cores.
(*c*) loosely-bound atoms in the body.
(*d*) a large number of conduction-electrons in the body.

(4) For the same current to pass, the speed of electrons in a wire will be... . if the wire is thick than if it is thin. [less, more]

(5) Resistance of a carbon filament......with the increase in temperature. [increases, decreases]

(6) Resistance of an electrolyte......with the increase in temperature. [increases, decreases]

(7) When you switch on an electrical appliance at home, you have a/an......circuit. [open, closed, short, series]

(8) When an electric field is applied across a metal,

(*a*) it greately accelerats the electrons.
(*b*) it only changes the direction of motion of the electrons but does not increase their speed.
(*c*) the acceleration of electrons is in the direction of the electric field and is small.
(*d*) the acceleration of electrons is small but can be in any direction.

(9) When no P.D. is applied, no current flows through a wire because

(*a*) the motion of the electrons is in all possible directions.
(*b*) the electrons are at rest.
(*c*) the electrons move along the wire with constant speed without acceleration.
(*d*) the electrons collide with imperfections.

(10) When there is no electric field, there is no current in a circuit because

(*a*) the electrons do not move at all.
(*b*) as many electrons move in one direction as in another.
(*c*) the electrons and the ions move with the same velocity.
(*d*) the resistance is infinite.

(11) For a given P.D., the current in a circuit is proportional to

(*a*) the volume of the wire.
(*b*) the cross-section and inversely to the length of the wire.
(*c*) the length and inversely to the cross-section of the wire.
(*d*) the inverse of the volume of the wire.

(12) Which one of the following materials would you choose for making the coils of a resistance box ?

(*a*) copper ; (*b*) brass ; (*c*) constantan ; (*d*) steel.

(13) Resistance will be more if the wire is ... [thick, thin]

(14) Resistance of a wire will......if it is made hollow.
[remain same, increase, decrease]

(15) Specific resistance of a wire will......if it is made hollow.
[remain same, increase, decrease]

(16) Specific resistance generally......with temp.
[increases, decreases]

(17) You have two copper wires of 50 and 100 cm. lengths, and 1 and 2 mm. in diameters respectively. Then the sp. resistance of......

(*a*) thicker wire is more. (*b*) thinner wire is more.

(*c*) both is same.

(18) The unit of sp. resistnnce is......
[mho, ohm, ohm × cm., ohm per cm., ohm per cm^3]

(19) Total resistance...... when several conductors are joined in parallel and......when they are arranged in series.
[decreases, remains same, increases]

(20) A galv. can be converted into an ammeter by using a

(*a*) low resistance in series. (*b*) low resistance in parallel.

(*c*) high resistance in series. (*d*) high resistance in parallel.

(*e*) potential divider.

(21) Resistance of a milliammeter is..... than that of an ammeter.
[less, greater]

(22) To convert an ammeter into a milliammeter, the resistance of the shunt has to be...... [increased, decreased]

(23) Deflection of a M.C. ammeter for a given current will...... if the strength of the magnet were increased. [increase, decrease]

(24) A galv. can be converted into a voltmeter by using a

(*a*) low resistance in series. (*b*) low resistance in parallel.

(*c*) high resistance in series. (*d*) high resistance in parallel.

(*e*) potential divider.

(25) Resistance of an ideal voltmeter will be...... [zero, infinite]

(26) Resistance of a millivoltmeter will be......than that of a voltmeter. [less, greater]

(27) A student has ten 0·1 ohm resistors. The maximum resistance he can make with them is......ohm/ohms. [1, 2, 5, 10]

(28) A student has ten 0·1 ohm resistors. The smallest resistance he can make using all of them is......ohm. $[\frac{1}{10}, \frac{1}{100}, \frac{1}{200}, \frac{1}{250}]$

(29) Whenever P.D. across the two ends of a conductor is

measured with the help of a voltmeter, the accuracy of the reading is......

(*a*) $<100\%$ (*b*) $= 100\%$ (*c*) $>100\%$

(30) ......is an application of Wheatstone's Bridge.

[P.O. Box, Potentiometer]

(31) Accuracy of results given by a Metre Bridge is......that given by a P.O. Box.

(*a*) less than (*b*) equal to (*c*) greater than

(32) If r be the internal resistance of a cell and R the resistance of its external circuit, then for obtaining maximum current we should connect several similar cells in series, if

(*a*) $R \ll r$ (*b*) $R = r$ (*c*) $R \gg r$.

(33) For obtaining maximum current, we should connect several similar cells in parallel, if

(*a*) $R \gg r$ (*b*) $R = r$ (*c*) $r \gg R$.

(34) For obtaining maximum current, cells should be connected in a Mixed Grouping, if

(*a*) $R \gg r$ (*b*) $r \gg R$ (*c*) none of these two.

(35) Internal resistance of a dry cell is much......than that of the wet Leclanche cell.

[more, less]

(35) A potentiometer is an ideal instrument for measuring P.D. or E.M.F. because

(*a*) it has a long wire.

(*b*) it uses a sensitive galvanometer.

(*c*) it does not disturb P.D. it measures.

(*d*) it is an elaborate arrangement.

III. Choose the correct statements :

(1) The electric current in a wire is due as much to positive ions going one way as electrons going the other way.

(2) Standard resistances are made of manganin or constantan because these metals have negligible temperature-coefficient.

(3) Specific resistance is numerically equal to the resistance offered between the opposite faces of one cm. solid cube of wire.

(4) 1 ohm $= 9 \times 10^{11}$ e.m.u. of resistance.

(5) 1 ohm $= 10^{9}$ e.s.u. of resistance.

(6) 1 ampere $= 3 \times 10^{9}$ e.s.u. of current.

(7) 1 e.m.u. of charge $= 3 \times 10^{10}$ e.s.u. of charge*.

(8) 1 e.m.u. of potential $= \frac{1}{3 \times 10^{10}}$ e.s.u. of potential.

---

*$c = 3 \times 10^{10}$ cm/sec. is the velocity of light in air.

(9) 1 e.m.u. of capacity = $(3\times10^{10})^2$ e.s.u. of capacity.

(10) 1 e.m.u. of current = 3×10^{10} e.s.u. of current.

(11) A fuse wire has a high resistance.

(12) For a thin wire, resistadce has a low value.

(13) For a thin wire, sp. resistance has a low value.

(14) For a longer wire, sp. resistance has a high value.

(15) On applying pressure to a metal, the amplitude of atomic vibrations decreases. This would cause a decrease in the electrical conductivity.

(16) E.M.F. of a cell is numerically equal to the work done by the cell per second in maintaining a unit current.

(17) E.M.F. of a cell is numerically equal to the work done in joules per coulomb of electricity taken in a circuit in which the cell is connected across a 1-ohm resistance.

(18) E.M.F. of a cell varies with the current flowing through the cell.

(19) Fall of potential along a uniform wire is also uniform.

IV. Matching Test :

Column A	*Column B*
(1) $s=\frac{R.a}{l}$ denotes	(*a*) mixed grouping.
(2) $E-V=C.r$ measures	(*b*) internal resistance by Potentiometer method.
(3) Current flowing in the conductors will be the same when they are joined in	(*c*) sp. resistance.
(4) Potential difference between the ends of each conductor will be the same when they are joined in	(*d*) lost-volt in a cell.
(5) $C=\frac{E}{2}\sqrt{\frac{m\,.\,n}{r\,.\,R}}$ gives maximum current for cells in	(*e*) parallel.
(6) $r=\frac{l_1-l_2}{l_2}\times R$ gives	(*f*) series.

CHAPTER XLIII

HEATING EFFECT OF CURRENTS

I. Completion Test :

(1) Joule's Law of heating states that the amount of heat produced in a conductor is directly proportional to the......of the current, ...of the conductor and the ...... of passing the current.

(2) ...... filament is used in incandescent lamps, and is more serviceable than......

(3) Coiled-coil lamps are ...... than straight filament lamps.

(4) Wattage=......×......

(5) A 40 watt-220 volt lamp has......resistance than a 40 watt-110 volt lamp.

(6) A straight filament lamp loses......heat than the coiled coil lamp.

(7) Fuse wire has......melting point. It is made up of......

(8) ......wires are used in the staircase wiring.

(9) ...... or ...... is used for making resistance coils while...... is used as an element of the heater.

(10) If temp. is to be measured with a potential-measuring device, we should need......

(11) Thermopile is a ...... of several... -

(12) The resistance of a filament when hot will be...... In other words, the amount of heat produced will increase when the resistance of the wire......

(13) A......converts heat energy into electrical energy.

II. Selection Test :

(1) An electron of mass M kg and charge Q coulombs travels from rest through a P.D. of V volts. Its final energy is... joules. [Q/V ; $Q.V$; $M\,Q.V$; $Q.V/M$; Q^2V^2/M]

(2) Themocouple is formed by the combination of......different metallic wires. [two, three, four]

(3) Thermocouple is used for ... [converting heat energy into chemical or electrical energy or detecting more heat in the furnace]

(4) Lamps used for household lighting are connected in...... while for street lighting they are connected in...... [parallel, series]

(5) Thermopile is used for ...... [storing the electrical energy, measuring the heat energy or radiant energy]

(6) A 3°C rise in temp. is observed in a conductor by passing a certain current. When the current will be doubled, the rise in temp. will be......°C. [15, 20, 9, 12]

(7) Certain substances lose their electrical resistance at very low temp. These substances are called

(*a*) insulators (*b*) semi-conductors

(*c*) good conductors (*d*) super-conductors.

(8) ......invented electric lamp and ...... discovered thermo-electricity.
[Seebeck, Thomas Edison, Newton]

(9) The resistance of a tungsten wire ...... with temp.
[increases, decreases]

(10) There are three electrical bulbs of 25 watts, 60 watts and 100 watts rated for 250 volts. The ...... watt lamp will have the highest resistance. [25, 60, 100]

(11) If two bulbs of 25 and 100 watts, rated at 250 volts, are connected in series across a 440-volt supply,

(*a*) both the bulbs will fuse. (*b*) 25-watt bulb will fuse.

(*c*) 100-watt bulb will fuse. (*d*) none of the bulbs will fuse.

(12) Two bulbs, one of 50 watts and another of 25 watts are connected in parallel to the mains. The current

(*a*) through the 50-watt bulb is more.

(*b*) through the 25-watt bulb is more.

(*c*) is same in the two bulbs.

(*d*) is difficult to be determined from the given data.

(13) The two bulbs of Q. 12 are connected in series to a 220 volt line. Then

(*a*) the potential drop across the two bulbs is the same.

(*b*) the potential drop across the 25-watt bulb is greater than that across the 50-watt bulb.

(*c*) the potential drop across the 50-watt bulb is greater than that across the 25-watt bulb.

(*d*) the potentinal drop across both the bulbs is 200 volts.

(14) You have the following appliances each of 500 watts running on 220 volts : (*a*) electric iron, (*b*) electric lamp, (*c*) electric room-heater. The electric resistance is

(*a*) maximum for the heater.

(*b*) maximum for the lamp.

(*c*) maximum for the electric iron.

(*d*) same in all the three cases.

(15) The amount of current flowing through a household circuit depends upon

(*a*) the resistance of the entire circuit.

(*b*) the P.D. which forces the current to flow through the circuit.

(*c*) both *a* and *b*. (*d*) neither *a* nor *b*.

(16) If a lamp-bulb is operated below the voltage marked on it,

(*a*) the consumption of electricity will be high.

(*b*) the bulb will not last long.

(*c*) the light will not be dim. (*d*) the fuse will blow.

(17) All the electrical appliances in a home are connected in ...... while main switches and fuses are connected in......

[series, parallel]

(18) It is ...... to use a thick piece of copper wire to replace a burnt-out fuse. [dangerous, useful]

(19) For measuring the strength of an A.C., we can use

(*a*) a hot-wire ammeter. (*b*) a galvanometer.

(*c*) a moving coil ammeter. (*d*) all of the above.

(*e*) none of the above.

(20) Power is transmitted from a power house on high voltage A.C. as

(*a*) the rate of transmission is faster at high voltage.

(*b*) it is more economical due to less power wasted.

(*c*) power cannot be generated at low voltage.

(*d*) a precaution against theft of transmission lines.

(21) Kilowatt × year is the unit of

(*a*) electrical power. (*b*) electrical energy.

(*c*) resistance. (*d*) capacity.

(22) ......gas is used in electric bulbs to protect them from fusing on account of any increase in the supply voltage.

[Hydrogen, Oxygen, Inert]

(23) Neon lamps are......expensive to use than ordinary light bulbs. [less, more]

CHAPTER XLIV

CHEMICAL EFFECT OF CURRENTS

I. Completion Test :

(1) ......is the process of decomposition of an electrolyte by the passage of......electric current.

(2) The electrodes where the electric current enters and leaves a voltameter are called......and......respectively.

(3) ......are deposited on the anode and are..... charged.

(4) ......are deposited on the cathode and are......charged.

(5) During electrolysis, all......go to the cathode while Hydrogen is the only......which also goes to cathode.

(6) When a current of 1 ampere is passed for 1 sec. through an electrolyte, then the weight of the ion deposited is equal to its...–

(7) E.C.E. of hydrogen=......

(8) E.C.E. of an element=......×Eq. Wt. of the element.

(9) In a lead-storage type battery, the liquid (electrolyte) used is......

(10) ......electrodes are to be used in electrolysis of HCl.

II. Selection Test :

(1) ......is based on the process of electrolysis.
[Electroplating, Electrotyping]

(2) Manufacture of......is due to electrolysis.
[metals, chemicals, acids]

(3) Electrolysis helps in the purification of......
[acids, metals, mixtures]

(4) In electroplating,......is made base metal, *i.e.* the object to be electroplated.
[cathode, anode]

(5) Laws of electrolysis were given by......
[Fleming, Newton, Faraday]

(6) Electrodes are made up of......in a water voltameter.
[copper, gold, platinum]

(7) In the electrolysis of HCl, electrodes used are made of......
[copper, carbon, platinum]

(8) Two copper-plated platinum electrodes are immersed in a copper sulphate solution and a current is passed. Nothing appears to happen at first, but eventually the copper sulphate colour disappears and gases appear at the electrodes. This colourless electrolyte is......

(*a*) platinum sulphate solution.
(*b*) platinum hydroxide solution.
(*c*) copper hydroxide solution.
(*d*) dilute sulphuric acid.

(9) Hydrogen ions are......, [cations, anions]

(10) Metal ions are ..... [cations, anions]

(11) Oxygen ions are...... [cations, anions]

(12) Chlorine ions are...... [cations, anions]

(13) Anions are charged...... [positively, negatively, neutral]

(14) Cations are charged ...... [positively, negatively, neutral]

(15) One faraday is equal to ... coulombs.
[69470, 96740, 96470]

(16) Unit of E.C.E. is=...
[gm./amp./sec. ; gm.×amp./sec. ; gm.×coulomb]

(17) When a solution of silver nitrate is electrolysed, the weight of silver deposited on the cathode depends upon......

(*a*) equivalent wt. of silver ; (*b*) strength of solution ;
(*c*) time ; (*d*) current-strength ;
(*e*) temperature.

(18) When several voltameters are joined in series to a source of current, the weights of ions accumulated on various electrodes are proportional to

(*a*) the atomic weights of various elements.
(*b*) the electro-valency of various elements.
(*c*) the chemical equivalents of various elements.

(19) The capacity of a storage cell is measured in terms of......
[watt × hours ; ampere × hours ; volt × hours]

III. Choose the correct statements :

(1) Current is measured by an Ammeter.

(2) E.M.F. is measured by a Voltameter.

(3) Resistance is measured by a Voltmeter.

(4) Current can be measured from the definition of Faraday's First Law of Electrolysis.

(5) The electric current, in a telephone, flows more easily when there is a loose packing of carbon grains.

(6) Electrolytes pass D.C. but not A.C.

(7) Copper sulphate solution has ions in it. Therefore it conducts electricity.

CHAPTER XLV

ELECTRO-MAGNETIC INDUCTION AND ELECTRIC MACHINES

I. Completion Test :

(1) From the Laws of Electro-magnetic Induction,......and...... of induced current are given by Faraday's First Law,...... of induced current is given by Faraday's Second Law while......of induced current is given by Lenz's Law.

(2) The two parallel wires will......when the current is flowing in them in the same direction, otherwise they will...each other when current is flowing in opposite directions.

(3) In an induction coil, the number of turns for primary is...... than that in the secondary coil.

(4) ......current is given by an Induction Coil.

(5) In a step-up transformer, what is gained in......is lost in the......

(6) The secondary coil of a step-up transformer consists of...... turns of wires than that of a step-down transformer.

(7) An induction coil works with......current only.

(8) A transformer works on......current only.

(9) ......current is given by a transformer.

(10) ......are used in an A.C. generator while......are used in a D.C. generator for making connections to the external circuit.

(11) ......is a coil of wires that rotates in a motor or dynamo, between the magnetic poles.

(12) The metallic parts of the electric bell which is attracted by the electro-magnet is called......

(13) A relay is used in a......for long distance transmission of messages.

(14) House-wiring is done in such a way that all the electrical instruments can be connected in......with the power supply.

II. Selection Test :

(1) Laws of electro-magnetic induction were given by......
[Fleming, Faraday, Lenz]

(2) "Increase—Inverse ; Decrease—Direct" is......way of determining the direction of the induced current.
[Fleming's, Faraday's, Lenz's]

(3) "Induced current or E.M.F. opposes the very agency which created it" is......way of determining the direction of the induced current. [Fleming's, Faraday's, Lenz's]

(4) Lenz's Law is a consequence of the law of conservation of
(*a*) charge. (*b*) momentum. (*c*) mass. (*d*) energy.

(5) The induced current is directed by Fleming's......Rule while the direction of motion of the current-carrying conductor suspended in a magnetic field is given by Fleming's......Rule.
[Left-hand, Right-hand]

(6) An induced E.M.F. is produced when a magnet is plunged into a coil. The strength of the induced E.M.F. depends upon the ......

(*a*) temp. of the coil. (*b*) resistance of the wire of the coil.

(*c*) number of turns in the coil.

(*d*) speed with which magnet is moved.

(*e*) strength of the magnet.

(7) A metallic rod falls under gravity with ends pointing in the direction east and west. Then

(*a*) no E.M.F. is induced at all.

(*b*) an E.M.F. is induced in it as it cuts H.

(*c*) two E.M.F.s of equal but opposite signs are induced giving no net E.M.F.

(8) The E.M.F. generated in a generator is 11000 volts. If everything else remains the same but the magnetic field is doubled, the E.M.F. generated will be......volts.

(*a*) 11000 (*b*) 5500 (*c*) 2750 (*d*) 22000

(9) Principle of Induction Coil was enunciated by . ...

[Fleming, Faraday, Ruhmkorff]

(10) Induction Coil was designed by......

[Lenz, Faraday, Ruhmkorff]

(11) An Induction Coil has a soft iron core which is .....while that of a transformer is......

[horse-shoe type, circular, straight, rectangular, closed one]

(12) Dynamo works on the principle of

(*a*) induced magnetism. (*b*) induced electricity.

(*c*) electro-magnetic induction.

(13) Dynamo

(*a*) creates electric energy.

(*b*) converts mechanical energy into electrical energy.

(*c*) converts electrical energy into mechanical energy.

(14) The couple acting on an armature in an electric motor depends upon......

(*a*) the number of turns in the coil.

(*b*) the area of the coil and the number of turns.

(*c*) the strength of the field and the number of turns.

(*d*) the area of the coil and the strength of the field.

(*e*) all of these.

(15) What is the name of the device used to convert A.C. from a higher voltage to a lower voltage or *vice versa* ?

(*a*) wattmeter (*c*) commutator (*e*) resistor

(*b*) transformer (*d*) transistor (*f*) capacitor.

(16) Rectifiers are used to convert......

(*a*) electrical energy into mechanical energy.

(*b*) heat energy into electrical energy.

(*c*) high voltage to a low voltage. (*d*) A.C. to D.C.

(17) Transmission of power from Bhakra Dam Power House to Dehli is possible for

(*a*) D.C., (*b*) A.C., (*c*) both for *a* and *b*, (*d*) radio waves.

(18) ......invented telephone while......invented electric telegraphy. [Morse, Rontgen, Graham Bell]

(19) ......line wire/wires is/are used in a telephone circuit while ......line wire/wires is/are used in a telegraph circuit. [one, two, three]

(20) Moving-Iron Meters work in......circuit/circuits.

(*a*) only A.C. (*b*) only D.C. (*c*) both A.C. and D.C.

(21) Hot-Wire Ammeters Voltmeters work in... ..circuit/circuits.

(*a*) only A.C. (*b*) only D.C. (*c*) both A.C. and D.C.

(22) On Hot-Wire Ammeters, the scale graduations are......

[equidistant, unequidistant]

(23) In which of the following electrical appliances will A.C. fail to function where D.C. is normally used ?

(*a*) electric light ; (*b*) voltameter ;

(*c*) a heating element ; (*d*) a cathode-ray tube ;

(*e*) solenoid for an electro-magnet.

(24) Electric power is generally transmitted at long distances

(*a*) at high voltage and low current.

(*b*) at low voltage and high current.

(*c*) at same voltage and current.

(25) Electric power is transmitted from a power house on high voltage A.C. as

(*a*) the rate of transmission is faster at high voltage.

(*b*) a precaution against theft of transmission lines.

(*c*) it is more economical due to less power wasted.

(26) The speed of rotation of a fan is reduced by putting a rheostat in series with the fan. The supply is D.C. We consume

(*a*) less power than at full speed but less efficiently.

(*b*) less power than at full speed but more efficiently.

(*c*) the same power as at full speed.

(*d*) more power than at full speed.

III. Choose the correct statements :

(1) Mechanical energy is coverted into electrical energy by a dynamo.

(2) Electric motors and moving coil galvanometers are fundamentally the same.

(3) Transformers can work only with A.C.

(4) Modern transformers have a core of mica as this is a good insulator.

5) We obtain A.C. from an Induction Coil.

(6) Induction coil can be used as a step-down transformer.

(7) In a dynamo, the e.m.f. of the induced current depends upon

(*a*) the number of turns in the coil.

(*b*) the strength of the field-magnets.

(*c*) the speed of rotation of the coil.

(8) The law of conservation of energy is obeyed by Lenz's Law.

(9) Morse key, Morse sounder and relay are the main parts of a telegraphic system.

(10) The current-impulse of a telephone transmitter increases when the carbon particles have more pressure acting on them.

(11) A solenoid carrying a soft-iron core is called an electro-magnet.

(12) On Hot-Wire Ammeters, the scale-graduations are marked as proportional to the square of the current.

(13) Commutator is a device used for converting D.C. into A.C.

(14) The frequency of A.C. mains in India is 50 cycles/sec.

(15) A motor can convert electrical energy into mechanical energy.

(16) Current taken by an electric motor cannot be calculated by dividing the applied volts by the resistance in ohms of the motor.

(17) There is an insulated piece of metal away from any electric or magnetic field. In any small portion of it, even though the electrons are moving freely, the net electric current is zero.

CHAPTER XLVI

ATOMIC PHYSICS

I. Completion Test :

(1) To produce electric discharge between two spherical conductors of 1 cm. radius and placed 1 cm. apart in air, a potential difference of about......volts is required.

(2) To produce electric discharge between two sharp points kept 1 cm. apart in air, a P.D. of about......volts is required.

(3) The length of a discharge tube used for the production of cathode rays is nearly......and its diameter is about......

(4) ......takes place inside a discharge tube at a pressure of 2 to 3 cm. of Hg. when local glows appear on the electrodes while the rest of the tube is completely dark.

(5) The continuous and luminous column filling the whole discharge tube between its electrodes at a pressure of about 1 cm. of Hg. is known as......

(6) In a discharge tube, ... appears between the positive column and the negative glow at a pressure of about 0·5 mm. of Hg.

(7) In a discharge tube, at a pressure of about 0·1 mm. of Hg, another dark space known as......appears between the cathode and the negative glow.

(8) When the pressure inside a discharge tube is reduced to ......, the production of cathode rays takes place.

(9) Cathode rays produce a fluorescence of......colour where they strike the wall of the discharge tube made from soda glass.

(10) In fluorescent lamps the material that emits ultra-violet radiations is......

(11) Cathode rays are......travelling with a velocity of......, depending upon the potential difference applied between the electrodes of the discharge tube.

(12) Cathode rays are......by an electric field......by a magnetic field.

(13) X-rays are produced when......strike a metal of......atomic number.

(14) X-rays travel......and carry......charge and travel with a velocity of......

(15) X-rays have the power of killing......

(16) ..., ...and......are the three types of rays emitted by a radioactive substance.

(17) The α-rays are......charged, β rays rays are......charged while γ-rays are......charged.

(18) γ-rays are......, β-rays are......and α-rays are......

(19) Rays consisting of helium nuclei are called......

(20) At the time of emission, a β-particle is always accompanied by another tiny particle called......

(21) ..... and......constitute the nucleus of an atom and not......

(22) Starting from the inner-most orbit of an atom around its nucleus, the maximum number of electrons which can be accomodated by various orbits is......

(23) ......are the atoms of an element, having same chemical properties (or same atomic number) but different atomic weights.

(24) ......are the atoms of an element, having same atomic weights but different chemical properties (or different atomic numbers).

(25) The radiant energy from the sun is due to......

(26) ......is the phenomenon in which a series of spontaneous atomic fissions take place without outside intervention.

(27) Radio-active substances......energy continuously.

(28) ......atoms are transmuted into other atoms.

(29) Particle which is used for causing nuclear fission is......

(30) Uranium splits into two parts on absorbing a/an......

(31) An arrangement for uncontrolled chain-reaction is called a/an......

(32) An arrangement for controlled chain-reaction is called a/an......

(33) An arrangement for controlled chain-reaction producing plutonium is known as a/an......

II. Selection Test :

(1) On boring a hole in the cathode of a discharge tube at the time of production of cathode rays, we get......rays on the backside of the cathode. [positive, canal, cathode]

(2) On boring a hole in the anode of a discharge tube at the time of production of cathode rays, we get......rays on the backside of the anode. [positive, canal, cathode]

(3) Cathode rays travel in...... [st. lines, wave form]

(4) To produce cathode rays, we apply a P.D. of......type between the electrodes of a discharge tube. [D.C., A.C.]

(5) When fast-moving electrons are stopped suddenly at a metal target in a partially evacuated tube, ...

(*a*) alpha particles are produced

(*b*) X-rays are produced (*c*) heat is produced

(*d*) metal becomes radioactive (*e*) metal burns.

(6) To produce X-rays, we apply a P.D. of......type between the electrodes of an X-ray tube. [D.C., A.C.]

(7) X-rays travel in...... [st. lines, wave form]

(8) The velocity of X-rays in vacuum is......the velocity of light in vacuum. [greater than, equal to, less than]

(9) X-rays are

(*a*) deflected by a magnetic field.

(*b*) deflected by an electric field.

(*c*) not deflected by a magnetic field but deflected by an electric field.

(*d*) not deflected by a magnetic field as well as by an electric field.

(10) X-rays......the laws of reflection, refraction, interference, diffraction and polarisation, just like light. [obey, do not obey]

(11) Generation of X-rays is an illustration of the

(*a*) phenomenon of conversion of K.E. into radiant energy.

(*b*) principle of conservation of mass.

(*c*) principle of conservation of momentum.

(*d*) phenomenon of conversion of mass into energy.

(12) When an X-ray beam is incident on a crystal, it

(*a*) cannot penetrate the crystal at all.

(*b*) can penerate to a depth of a few atomic dimensions.

(*c*) can penerate about a centimetre.

(*d*) can penerate any thickness.

(13) The penetrating power of X-rays increases with the

(*a*) increase in their velocity.

(*b*) increase in their frequency.

(*c*) decrease in their frequency.

(*d*) increase in their intensity.

(14) The energy of an X-ray photon is $3{\cdot}31\times10^{-9}$ ergs. Its frequency per second would be (when Planck's constant $=6{\cdot}62\times10^{-27}$ erg × sec.)......

(*a*) 5×10^{17} (*b*) 2×10^{17} (*c*) $6{\cdot}62\times10^{-18}$ (*d*) 2×10^{-18}

(15) X-rays do not help us in the

(*a*) study of crystal symmetry.

(*b*) measurement of distances between atoms in a crystal.

(*c*) study of crystal surface. (*d*) study of crystal structure.

(16) X-rays are......to the human eye. [invisible, visible]

(17) Penetrating power of X-rays......with the density of the material. [increases, decreases]

(18) Efficiency for the production of X-rays is

(*a*) 100% (*b*) 99% (*c*) 50% (*d*) less than 1%

(19) Elements of higher atomic weight absorb X-rays...readily than those of lower atomic weight. [more, less]

(20) X-rays...electrons from the surface of metals on which they fall. [liberate, do not liberate]

(21) Under the action of a magnetic field, α-rays bend..., β-rays bend...and γ-rays bend...... [not at all, less, more]

(22) An alpha particle

(*a*) does not interact with electrons.

(*b*) interacts with electrons through electrostatic forces.

(*c*) interacts with electrons through gravitational forces.

(*d*) interacts with electrons through nuclear forces.

(23) In interacting with an electron, an alpha particle

(*a*) loses most of its energy.

(*b*) abruptly changes direction.

(*c*) does not lose energy at all.

(*d*) loses a small fraction of its energy.

(24) In its interaction with an alpha particle, the energy gained by an electron

(*a*) is retained by it. (*b*) appears finally as light.
(*c*) is distributed amongst other electrons.
(*d*) appears finally as sound.

(25) What is the correct composition of helium atom ?

(*a*) 1 proton, 1 neutron and 1 electron.
(*b*) 2 protons, 1 neurton and 1 electron.
(*c*) 1 proton, 2 neutrons and 2 electrons.
(*d*) 2 protons, 2 neutrons and 2 electrons.

(26) Average radius of the nucleus is of the order of

(*a*) 10^{-8} cm. (*b*) 10^{-10} cm. (*c*) 10^{-13} cm. (*d*) 10^{-16} cm.

(27) The mass of a nucleus is 20 times the mass of a proton which is $1{\cdot}67 \times 10^{-24}$ gm. Then the density of the nucleus is of the order of

(*a*) 1 gm./c.c. (*b*) 20 gm./c.c.
(*c*) 10^7 gm./c.c. (*d*) 10^{-15} gm./c.c.

(28) When combined in a nucleus, the total mass of the protons and neutrons is less than the sum of their individual masses. This suggests that......

(*a*) 'mass defect' is due to electrons surrounding the nucleus.
(*b*) there is some unaccounted-for particle in the nucleus.
(*c*) 'mass defect' accounts for the energy of electrons surrounding the nucleus.
(*d*) 'mass defect' accounts for the 'binding energy' holding the particles together in the nucleus.

(29) The nuclear force is

(*a*) much greater than Coulomb and gravitational forces.
(*b*) stronger than the gravitational force but not the Coulomb force.
(*c*) stronger than the Coulomb force but not the gravitational force.
(*d*) weaker than Coulomb and gravitational forces.

(30) Electrons in an atom are held in the atom by

(*a*) Coulomb forces (*b*) Van-der-Waals forces
(*c*) Nuclear forces (*d*) gravitational forces.

(31) A meson captured in an atomic orbit has

(*a*) positive charge and mass equal to that of an electron.
(*b*) negative charge and mass equal to that of an electron.

(*c*) positive charge and mass 207 times that of an electron.

(*d*) negative charge and mass 207 times that of an electron.

(32) The process in which nuclei join to form a new nucleus and liberate heat is known as

(*a*) catalysis (*b*) fusion (*c*) fission (*d*) electrolysis.

(33) When an atom is split into two or more parts, the process is called......

(*a*) fusion (*b*) fission (*c*) radioactivity*

(*d*) an uncontrolled chain-reaction.

(34) The process of fission occurs primarily in...

(*a*) nuclear reactors ; (*b*) sun ; (*c*) hydrogen bomb ;
(*d*) atom bomb ; (*e*) chemical reactions.

(35) The half-life of a radioactive element depends upon

(*a*) temperature ; (*b*) pressure ;

(*c*) amount of the element present ;

(*d*) what the element is chemically combined with ;

(*e*) none of the above.

(36) Nuclear fission was experimentally observed by

(*a*) Planck. (*b*) Fermi. (*c*) Rutherford.

(*d*) Hahn and Strassman.

(37) Unstable nucleus U^{236} will

(*a*) emit α-rays. (*b*) emit β-rays. (*c*) emit γ-rays.

(*d*) break-up into two lighter nuclear fragments.

(38) Soon after fission, the fragments emit

(*a*) X-rays. (*b*) visible light.

(*c*) neutrons. (*d*) ultraviolet light.

(39) The β-ray emitted by a radioactive substance is

(*a*) an electron and comes from electron-orbits outside the nucleus.

(*b*) an electron which was existing within the nucleus.

(*c*) an electron emitted by the nucleus due to the decay of a neutron inside the nucleus.

(40) In electron-positron annihilation, there is

(*a*) conservation of number of particles.

(*b*) conservation of energy only.

(*c*) conservation of momentum only.

(*d*) conservation of both energy and momentum.

---

*Unit of radioactivity is a **rutherford** which is the quantity of radioactive material which undergoes 10^6 disintegrations per second. Thus, 37 rutherfords =1 millicurie. (In a curie, number of disintegrations per second $= 3{\cdot}7 \times 10^{10}$).

(41) The critical mass of fissionable uranium 235 can be reduced by

(*a*) adding impurities to U^{235}.
(*b*) heating the material. (*c*) cooling the material.
(*d*) surrounding it by neutron reflecting material.

(42) The rate of self-sustaining chain-reaction in a mass of pure U^{235} will decrease

(*a*) if the amount is less than the "critical mass".
(*b*) if the mass is just equal to the "critical mass".
(*c*) if the amount exceeds the "critical mass".
(*d*) always.

(43) A nuclear reactor uses as a fuel

(*a*) lead (*b*) beryllium (*c*) heavy water
(*d*) uranium (*e*) graphite (*f*) zirconium
(*g*] plutonium (*h*) cobalt (*i*)titanium

(44) Which of the following is/are used as a moderator in a nuclear reactor ?

(*a*) heavy water (*b*) graphite (*c*) cobalt
(*d*) titanium (*e*) cadmium (*f*) lead

(45) For nuclear fission, Einstein's mass-energy relation is

(*a*) $E=m.v$ (*b*) $E=m.c^2$ (*c*) $E=F\times s$

(46) During nuclear fission, ...energy is released by 1 kg. of uranium.

(*a*) 9×10^{23} ergs. (*b*) 9×10^{16} watts × sec.
(*c*) 9×10^{14} joules.

(47) Cosmic rays refer to

(*a*) X-rays coming from the sun.
(*b*) X-rays coming from a star in the Milky Way.
(*c*) high energy uncharged particles coming from outer space.
(*d*) high energy charged particles coming from outer space.

(48) The number of electrons emitted per second from a metal, when light falls on it, increases with

(*a*) increasing number of photons.
(*b*) increasing frequency of photons.
(*c*) increasing wavelength of photons.
(*d*) increasing velocity of photons.

(49) Electro-magnetic field is radiated by

(*a*) a stationary charge only.

(*b*) a charge in uniform motion only.

(*c*) an accelerated charge only.

(*d*) both an accelerated charge and a charge in uniform motion.

(50) Electromagnetic wave is emitted by an atom when

(*a*) electron jumps from a high energy stationary orbit to a low energy stationary orbit.

(*b*) electron is rotating in a stationary orbit.

(*c*) electron jumps from a stationary orbit into the nucleus.

(*d*) electron in the atom collides with another electron in the atom.

(51) Which of the following are electro-magnetic in nature ?

(*a*) infra-red rays. (*b*) ultra-violet rays. (*c*) X-rays. (*d*) α-rays. (*e*) β-rays. (*f*) γ-rays. (*g*) wireless waves. (*h*) radar waves. (*i*) T.V. waves.

(52) Which of the following can be deflected by magnetic fields ?

(*a*) electrons. (*b*) neutrons. (*c*) hydrogen atoms. (*d*) alpha particles. (*e*) sodium ions.

(53) A cloud chamber

(*a*) shows up any particle tracks.

(*b*) shows up tracks of ionized particles only.

(*c*) shows tracks which consist primarily of ionized particles.

(*d*) shows tracks which consist primarily of condensed vapours.

(*e*) is used for the study of radioactive decay processes.

(54) Which of the following has the shortest wavelength ?
[visible light, ultra-violet rays, gamma rays, X-rays]

(55) ...are emitted when the filament of a diode or triode valve is heated and...... gets a +ve charge.
[protons, electrons, positrons, plate, grid]

(56) When a metal is heated in a vacuum, it

(*a*) expands. (*b*) burns. (*c*) emits light.

(*d*) emits electrons. (*e*) emits alpha particles.

III. Tick-Mark Test (*i.e. Choose the correct statements*) :

(1) Number of protons in the nucleus exhibits the chemical identity of the atom.

(2) Uranium (U^{235}) is the basic fuel for a nuclear reactor while plutonium (Pu^{239}) is an artificial fuel.

(3) Only 0·7% of U^{235} is present in the natural uranium while the rest is U^{238}.

(4) By bombarding neutrons on U^{238}, it can be converted into fissionable plutonium 239.

(5) In a nuclear reactor, its efficiency increases with the rise of temperature of the steam.

(6) Atomic energy violates the law of conservation of energy.

(7) Law of conservation of energy is violated by the electromagnetic induction.

(8) In a nuclear reactor, cadmium is used to absorb neutrons and hence controls the reaction.

(9) The screen in an iconoscope consists of many photo-electric cells.

(10) Light waves are reflected or refracted downwards by the ionosphere.

(11) The better the vacuum of the tube and higher the applied voltage, the shorter in wavelength and more penetrating are the X-rays.

(12) All isotopes of an element have the same number of protons in the nuclei of their atoms.

(13) An electron repels an electron, but it attracts a neutron.

(14) Isotopes of a radioactive element are not always radioactive.

(15) Most heavy atoms have more neutrons.

(16) The process of disintegration of radioactive elements cannot be hastened or delayed by physical or chemical means.

(17) Neutrino is electrically neutral and its mass is negligibly small.

(18) All the α-particles emitted by a given radioactive substance are emitted with the same velocity.

(19) β-particles from a given radioactive source are emitted with different velocities, varying from zero to a certain maximum.

(20) Radioactivity and fission are the same.

(21) Radioactivity can never be induced in a stable nucleus.

(22) Radioactivity can be artificially induced in a stable nucleus.

(23) Radioactivity is a phenomenon associated with the decay of atoms.

(24) Decay of a radioactive substance cannot be hastened or delayed by physical or chemical means.

(25) An electric bulb cannot be used as a thermionic valve.

IV. Matching Test :

Column A	*Column B*
(1) Discoverer of radio-activity.	(*a*) Lord Rutherford
(2) Discoverer of nuclear fission.	(*b*) J.J. Thomson and Milikan
(3) Discoverer of electron.	(*c*) Anderson
(4) Discoverer of proton.	(*d*) Strassman and Hahn
(5) Discoverer of positron.	(*e*) Chadwick
(6) Discoverer of neutron.	(*f*) Madam Curie
(7) A device by means of which light energy is converted into electrical energy.	(*g*) electric eye or photo-electric cell
(8) Natural radioactive element.	(*h*) 3×10^7 metres/sec.
(9) Radio-isotopes are detected by	(*i*) Radium
(10) Practical application of a discharge tube.	(*j*) Gieger counter
(11) During fission, chain-reaction is caused by	(*k*) 3×10^8 metres/sec.
(12) Speed of the electron revolving in orbit around the nucleus of an atom.	(*l*) Neon signs
(13) Speed of wireless waves.	(*m*) neutron

Short-Answer Questions

1. *(a) What do you mean by an electric current? (b) What is the simplest way of getting such a current continuously* (**or** *what is a cell*)?

Ans. (a) : It is the flow of electrons which constitutes an electric current. The strength of an electric current is measured by the rate of flow of charge along any path.

(b) : When two conductors at different potentials are brought in metallic contact, the charge (or electrons) will start flowing in the connecting wire till both the conductors come at the same potential. But here, the electric current will be available for a very very small interval of time. Hence our choice falls upon a **cell** *which is a device, method or arrangement to keep two conductors at different potentials even when they are externally connected* and thus a continuous current is made available in the external circuit.

2. *What happens when two different conductors are brought in contact?*

Ans. In this position, the free or conduction electrons (of outermost orbit) of one material diffuse into those of the other material. With the diffusion of electrons, there will be a potential difference (called *contact potential*) between the two conductors (*e.g.* voltaic pile). With the increase of contact, the rate of diffusion will increase and so P.D. will also be increased.

3. *How can the contact potential difference be explained in the case of a simple or voltaic cell?*

Ans. The flow of electric current by a simple cell will be developed by the contact potential difference. A Zn^{++} goes into solution from the zinc rod. But H_2SO_4 acid must remain electrically neutral ; so for each Zn^{++}, two H^+ leave the solution, by taking the elecrons from the copper rod and becoming hydrogen atoms. Hydrogen atoms being neutral will rise to the top of the electrolyte as a gas. The deficiency of two electrons of copper will be compensated by zinc rod connected externally, causing thereby a steady flow of electric current through the wire from zinc to copper.

4. *There is no reaction between pure Zn and H_2SO_4. But the reaction starts as soon as Cu and Zn plates of a simple cell are connected externally by a conducting wire. Why is it so?*

Ans. Contact potential between Cu and H_2SO_4 is $+0{\cdot}46$ volt while that between Zn and H_2SO_4 is $-0{\cdot}62$ volt. Evidently, in a voltaic cell where *Cu* and *Zn* rods are dipped in a solution of H_2SO_4, these metals will attain as well as maintain their contact potentials. Here *Cu* is at higher potential and *Zn* at lower potential. Whenever *Cu* and *Zn* are connected externally by a wire, the (+ve) charge starts flowing from *Cu* to *Zn* in the external circuit and *Zn* to *Cu* inside the cell so as to complete the electrical circuit. This will try to bring both *Cu* and *Zn* at the same potential. But these have to retain or maintain their contact potentials as long as they are dipped in H_2SO_4. This objective is achieved by instigating a chemical reaction between *Zn* and H_2SO_4 as given below :

$$Zn+H_2SO_4=ZnSO_4^{--}+2H^+$$

$ZnSO_4^{--}$ gives its negative charge to *Zn* rod and it itself settles down at the bottom of the cell while H^+ goes to *Cu* plate, delivers its +ve charge and bubbles out of the electrolyte.

[**Note** : It is also now clear that the *source of electrical energy in a cell is the chemical reaction* that takes place between the —ve plate and the electrolyte.]

5. *Why is the jar of a Leclanche cell painted black near the top ?*

Ans. In the Leclanche cell, a saturated solution of ammonium chloride is used as an electrolyte. With the evaporation of water, the surplus ammonium chloride deposits in the form of fine crystals on the walls of the cell. These crystals grow and show a tendency of creeping even to the outside of the cell. To prevent this creeping, the black pigment is used.

6. *Why is a Leclanche cell so consistently used whenever an intermittent current is required ?*

Ans. It is due to two reasons :

(*i*) When *Zn* reacts with ammonium chloride, *ammonia gas* is also released. If the cell is used continuously, this pungent gas will fill the whole room and will oust you.

(*ii*) In this cell, the depolariser is MnO_2* powder which cannot oxidise the hydrogen as fast as it is evolved. So hydrogen will force its way to carbon plate and a partial polarisation will set in when the cell is used for a long time and the voltage will drop.

[**Note** : If the cell is allowed to rest for some time, depolarisation is completed and the original E.M.F. is restored. It is for this reason that the light of a torch grows dim when put on for a long time but it begins to burn brightly when it is switched off for a short time and then switched on.]

7. *What is the purpose of mixing MnO_2 with graphite or carbon particles in a Leclanche cell ?*

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* MnO_2 oxidises hydrogen and is itself converted into Mn_2O_3 which is not an oxidising agent. After some time all the MnO_2 will be converted into Mn_2O_3. By the oxygen of atmosphere, Mn_2O_3 keeps on being oxidised to MnO_2. This is called **auto-oxidation**.

Ans. MnO_2 is a solid and a bad conductor of electricity. The carbon or graphite particles make it conducting and hence the two are mixed together.

8. *What precautions should be observed for a Leclanche cell ?*

Ans. (*i*) Unless very heavy currents are required, the solution should not be saturated—otherwise there will be *creeping* of the salt up the sides of the jar and up the porous pot. To avoid creeping, coat the mouth of pot from inside.

(*ii*) Loss of water by evaporation should be made up at regular intervals.

(*iii*) The cell should be in a ventilated place because ammonia will cause metal terminals, if damp, to corride.

(*iv*) Terminals should be coated with vaseline.

9. *Why can a Daniell cell be used in place of an accumulator ?*

Ans. An accumulator or battery or storage cell is a source of constant E.M.F. A Daniell cell also supplies a constant E.M.F. by removing two main defects (local action and polarisation) of a primary cell. Local action is removed through the use of a pure or an amalgamated zinc rod. Polarisation is removed by passing hydrogen through a saturated solution of $CuSO_4$ which consumes hydrogen (and replaces it by conducting Cu) as fast as it is evolved. There is a perforated shelf, near the top of the copper vessel, containing crystals of $CuSO_4$ to keep up the strength of the depolariser.

10. *Why is zinc rod not allowed to remain in the acid when the Daniell cell is not in use ?*

Ans. On account of *diffusion*, copper sulphate solution passes in through the pores of the porous pot. It reacts with zinc forming zinc sulphate and copper. These copper particles deposit on zinc plate and produce local action. Thus there would be a wastage of zinc.

11. *What is the cause of high internal resistance of a Daniell cell ? How can it be decreased ?*

Ans. *Cause* : Presence of the porous pot.

Remedies : (*i*) Do away with the porous pot by floating the $ZnSO_4$ solution on top of the heavier $CuSO_4$ solution. (Such cells are called **gravity cells**).

(*ii*) Use Zn in the form of a star so as to expose a large surface to the electrolyte **and** take Cu-electrode in the form of 3 plates riveted together at the centre so as to give a large surface.

12. *How will you test the polarity of a cell ?*

Ans. The polarity of a cell or the direction of the flow of current in a wire can be tested by **SNOW** Rule or Ampere's Swimming-man Rule. It can also be tested by taking two wires dipped in starch iodide solution. The anode will become blue due to the liberation of iodine.

13. *Under what conditions can electric charges affect magnets ?*

Ans. (*i*) The electric charge should be *in motion* so that an electric current is set up which will produce its own magnetic field ; and

(*ii*) The electric charge should not move perpendicular to the length of the magnet. Maximum effect will be when the charge moves parallel to the magnet.

14. *Why do we set the coil of the tangent galvanometer in the magnetic meridian ?*

Ans. Working of the tangent galv. is based on the Tangent Law, according to which

$$\frac{\text{Deflecting field } F}{\text{Controlling field } H}=\tan\theta$$

when F and H are at right angles to each other.

Here H is the earth's horizontal field along north-south direction and F is due to the current flowing in the coil. Since F has to be along east-west direction and also F is perpendicular to the plane of the current-carrying coil, therefore the coil must be set in a direction perpendicular to east-west. In other words, the plane of the coil must be set in the magnetic meridian.

15. *How will you check whether the coil of a Tangent Galvanometer is in the magnetic meridian or not ?*

Ans. Pass the current in the galv. and note the deflection* of the needle. Now reverse the direction of the current and again note the deflection. If both the deflections are equal, the coil is in the magnetic meridian otherwise not.

16. *What maximum current can be measured by a tangent galvanometer ?*

Ans. If C amperes be the current flowing in a tangent galv. of reduction factor K, so that a deflection of $\theta°$ is produced in the compass needle, then

$$C = 10.K.\tan\theta$$

Since K is a constant for a given galv., the maximum value of C depends upon the maximum value of tan θ which becomes infinite for $\theta=90°$. Hence a tangent galv. can measure the strongest possible currents upto infinity.

17. *Why should the magnetic needle of a tangent galvanometer be small ?*

Ans. The working of a tangent galv. is based on the Tangent Law in which two uniform and **coplanar** magnetic fields F and H act at right angles to each other. H, the horizontal component of the earth's magnetic field, is uniform over a fairly wide area of observation. But the field F produced by the electric current in the circular coil is non-uniform. It is fairly uniform over a small region round about the centre of the coil. Hence, If a short magnetic needle be placed at the centre, it can reasonably be assumed to move in a uniform field. This assumption will not obviously be justified if we use a long magnetic needle.

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* Read both ends of the pointer to remove error due to eccentricity. Reverse the direction of current and again read both ends of the pointer to remove error due to non-coincidence of the plane of the coil and the needle. Thus the mean of these four readings is the correct deflection.

[**Note** : But we cannot take a very small magnetic needle because then the restoring couple $M.H.\sin\theta$ will become so small that the friction at the pivot will become predominant and the deflections (specially for weaker currents) will not be reliable.]

18. *The aluminium pointer has been fixed at right angles to the magnetic needle of a tangent galvanometor. Can it not be fixed parallel to it ?*

Ans. The pointer can as well be fixed parallel to the needle, but in this position there will be one difficulty. In this case, while adjusting the coil in the magnetic meridian, the pointer will also fall below the coil when the eye is held vertically above it, and consequently there will be difficulty in the adjustment of the coil.

19. *In a tangent galvanometer, the aluminium pointer is not flat just like a plane strip but its broad side is vertical. Is there any special reason for this ?*

Ans. *Yes*. The shape is specially advantageous in two ways :

(*i*) The reading can be noted with greater accuracy on the scale on which the pointer's tip moves.

(*ii*) As the flat side of the pointer, when deflected, is subjected to greater resistance of air, it helps in damping the motion of the needle. In this instrument, damping due to air only is available, hence maximum advantage of air resistance is taken by imparting this shape to the pointer.

20. *In a tangent galvanometer, how is a choice for using different turns made ?*

Ans. The 2-turn coil is known as the *ammeter coil* and is used for measuring heavy currents. The 50-turn coil is used for currents of moderate strength. The 500-turn coil is known as the *voltmeter coil* and is used with weak currents.

21. *Why should a solenoid tend to contract when a current passes through it ?*

Ans. According to the law of parallel currents, like parallel currents attract and unlike parallel currents repel each other. Therefore, when current is passed through the coil of a solenoid, like parallel currents flow in its various turns which start attracting one another. As a result, the solenoid contracts.

[**Note** : The same principle is applied in Roget's Vibrating Spiral.]

22. *A beam of electrons is travelling from east to west. In which direction is the current flowing? A magnetic field is now applied towards Zenith. To which direction will the beam be deflected?*

Ans. The direction of flow of electrons is regarded as opposite to that of the conventional current which, in the given case, will flow from west to east. On applying a magnetic field towards Zenith (*i.e.* upwards), we see that the beam will deflect towards south by using Fleming's Left-hand Rule.

23. *Why is the coil of a M.C. Galvanometer wound on an aluminium frame?*

Ans. When the metallic frame is deflected, magnetic flux changes and eddy currents are produced inside the frame. These currents produce a magnetic field which opposes the motion of the coil and quickly brings it to rest. This does not alter the final deflection but only makes it quick reading. [Such galvanometers are called 'dead-beat'.]

Use of light metal makes the galv. more sensitive.

[**Note**: Eddy currents in electromagnets will produce heat which can be minimised by using laminated iron cores insulated from one another by a thin coating of varnish.]

24. *In a M.C. Galv., why is the magnetic field made radial?*

Ans. The moment of the deflecting couple is equal to $H.C.A.n$ when the plane of the coil always lies in the direction of the controlling magnetic field H. This will be so only when the field in-between the pole-pieces is *radial.* In this case only, the relation between the current and the deflection will be linear *i.e.* current will be directly proportional to the deflection and therefore the graduations on the scale will be equidistant.

25. *What difficulty will you experience if the magnetic field in a M.C. Galv. is not radial?*

Ans. If the field is not radial, the plane of the coil will not always be parallel to the field. In that case, if θ be the angle of inclination between the two, the moment of deflecting couple will be $H.C.A.n. \cos\theta$. Hence the relation between C and θ will not be linear and the graduations on the scale can never be equidistant since $\cos\theta$ is not directly proportional to θ. Moreover we do not measure the angle θ; we measure the deflection or displacement of the optical pointer with the help of a Lamp and Scale Arrangement. Obviously, if the field is parallel to the face of the coil at every instant, $\theta=0$ for the coil and consequently $\cos\theta=1$.

26. *How is the magnetic field made radial in a M.C. Galv.?*

Ans. Radiality of the field is realised by (*i*) properly cutting the pole-pieces, and (*ii*) using a soft iron core within the coil.

Pole-pieces cannot be flat. If the coil of the galv. is rectangular, the pole-pieces are cut in a concave cylindrical shape. In the case of circularly shaped coil, the pole-pieces are shaped spherical.

Soft iron core not only helps in making the field radial but also on account of its high permeability, the field strength between the pole-pieces becomes maximum—thereby making the galv. more sensitive.

27. *Why is phosphor-bronze alloy preferred for the suspension wire of a M.C. Galvanometer* ?

Ans. (*i*) It has *great tensile strength* so that even if it is thin it will not break under the weight of the coil suspended to it.

(*ii*) Its *torsional couple per unit twist is small.* Consequently the instrument is very sensitive.

(*iii*) It is *rust-resisting*. Hence it remains unaffected by the weather conditions of air in which it is suspended.

28. *Why is the suspension taken in the form of a strip in a M.C. Galvanometer* ?

Ans. The rectangular strip has a very small torsional rigidity and hence the twist for a given couple is much greater and the stress on the material much less than with a circular wire.

Further, a strip-type suspension offers a comparatively large area for the dissipation of heat produced by the current.

29. *What should be the properties of standard resistances* ?

Ans. (*i*) Permanence ; its value should not change with time.

(*ii*) Negligible variation with temp.

(*iii*) Robust construction and convenient size.

(*iv*) Capacity for carrying current without overheating.

(*v*) Very low inductance and self-capacitance.

[**Note** : Ohm's law does not hold good for semi-conductors (transistors) or radio valves or for the passage of electricity through gases or for conductors kept under tension or for conductors placed in a strong magnetic field.]

30. *What is the significance of doubling the resistance wire before wrapping it round the bobbin in the coil of a resistance box* ?

Ans. This arrangement gives the effect of two coils placed side by side (round the bobbin *K* - Fig. 7-17), carrying currents in opposite directions, so that the opposing induced current in one coil neutralises the opposing induced current through the other coil. The residual induced current is therefore zero. In other words, the main current in the resistance coil remains constant. Hence the coil always has a constant resistance. [Thus this *non-inductive winding* of the resistance wires is very essential.]

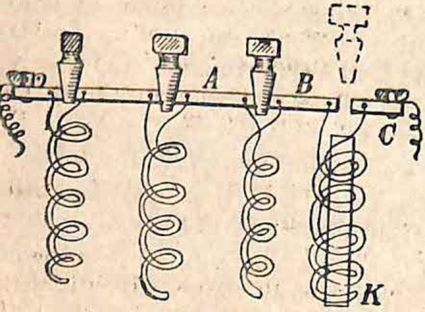

Fig. 7-17

[**Note** : In a resistance box when a particular plug is in, a very feeble current flows through the resistance wire and practically whole of the current flows through the brass blocks. The resistance of the wire is even then not included in the circuit because the wire and the brass resistance become in parallel and hence their effective resistance becomes less than the resistance of brass block even and therefore becomes negligibly small.]

31. *On a rheostat is written 2 amp. (CONT) and 2·5 amp. (INT). What do they mean? And why is this difference in the two values of these currents?*

Ans. It means that this rheostat can carry 2 amperes *constant* current and 2·5 amperes *intermittent* current without undue overheating or burning.

Since the resistance wire is closely wound on a rheostat, the heat generated by the passage of electric current is not radiated at once but it gets accumulated. If the current is passed continuously through a rheostat, the heat will be conserved for a long time and the temp. of the rheostat coil may rise considerably—resulting in overheating or burning.

However, if the current is used intermittently, heat does not accumulate - it is wholly or partly radiated during the time when no current is passing through the rheostat. Hence a higher current can be safely carried by the rheostat.

32. *A rheostat is generally used as a variable resistance. How can you use this as a potential divider?*

Ans. In Fig. (7-18) is shown a rheostat. The two ends of its resistance coil are tied at the terminals T, T while the sliding contact P can move left or right on a thick metallic rod R. To use it as a variable resistance, it is put in series in an electrical circuit with the help of its two terminals - T (any one) and A.

To use it as a *potential divider*, the whole of the input potential is applied to the end-terminals T and T. Since the wire of its resistance coil is of uniform cross section therefore there is a continuous or uniform fall of input potential from one end of the wire to the other. From this, a portion can be tapped for output by using the terminals A and T (any one of the two T, T).

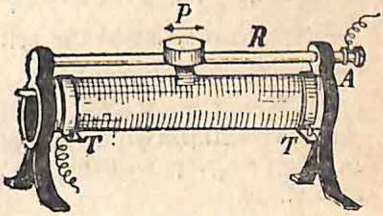

Fig. 7-18

[**Note** : A rheostat should be kept at a distance from such instruments (like Tangent Galv., Kelvin's Mirror Galv. and Astatic Galv.) which are likely to be disturbed by the magnetic field created in the rheostat which acts like a solenoid.]

33. *What do you mean by the E.M.F. of a cell?*

Ans. The difference of potential caused by the chemical action aking place inside a cell is called the E.M.F. of the cell. It is equal to the P.D. between its poles when the cell is on *open circuit* and is actually equal to the maximum P.D. which the cell is capable of generating. It is the E.M.F. which is responsible for maintaining a steady current in the external as well as in the internal circuit.

The current which flows from the cathode to the anode inside the cell starts flowing against the P.D. between the electrodes. Work must be done to drive this current. The necessary energy for this purpose is supplied by the chemical action in the cell. The cell, therefore, exerts a sort of force. This "force" due to chemical action is the E.M.F. The cell supplies a definite amount of energy to drive each unit of charge from one electrode to the other electrode. Hence the E.M.F. of a cell can be defined as *numerically equal to the work done by the cell per second in maintaining a unit current.*

[**Note :** E.M.F. is on open circuit of a cell and is concerned with the whole circuit (external as well as internal) at a time, while P.D. is on closed circuit of a cell and is concerned with the external circuit only (complete external circuit or part of the external circuit). Difference between E.M.F. and P.D. is called **Lost Volt**, *i.e.* the energy wasted inside the cell.]

34. *On what factors does the E.M.F. of a cell depend ?*

Ans. The E.M.F. of a cell depends upon :

(*i*) the temperature ;

(*ii*) the nature of the electrodes ; and

(*iii*) the concentration of the electrolyte.

35. *On what factors does the E.M.F. of a cell not depend ?*

Ans. The E.M.F. of a cell does not depend upon :

(*i*) the size of the cell ; and

(*ii*) the shape of the cell.

Hence the E.M F. of a cell will remain constant if its plates are partially withdrawn or moved further apart. But this will change the internal resistance of the cell and hence the current in the circuit will also change.

36. *What do you mean by the internal resistance of a cell ? On what factors does it depend ?*

Ans. The resistance offered by the electrolyte of a cell is called its internal resistance. It depends upon :

(*i*) the nature of the electrolyte ;

(*ii*) the distance between the plates of the cell (or the length of the electrolyte) ; and

(*iii*) the cross-sectional area of its plates.

Just as for a conductor, we have

$$\text{Resistance} = (\text{Sp. resistance}) \times \frac{\text{length}}{\text{cross-sectional area}}$$

Similarly for a cell, we can write :

Internal resistance

$$=(\text{nature of electrolyte}) \times \frac{\text{distance between plates}}{\text{area of plates}}$$

Thus for a given electrolyte, the internal resistance of a cell can be decreased by bringing the plates nearer and by increasing the size of plates.

37. *Why should the internal resistance of a cell be kept minimum ?*

Ans. $\because$ E.M.F. $-$P.D.$=$current $\times$ internal resistance

$=$lost volt

Therefore, to decrease the wastage of electrical energy (known as its lost volt) inside a cell, we should decrease its internal resistance.

38. *Why is the internal resistance of a dry cell much less than that of a wet Leclanche cell ?*

Ans. It is due to two reasons : (*i*) there is no porous pot, and (*ii*) the negative plate (the zinc container) completely surrounds the positive plate, from which the current flows out radially in all directions.

[**Note** : Internal resistance increases with the age of the cell (*i*) owing to the drying up of the jelly and paste and (*ii*) also due to the incrustation of the zinc.]

39. *What is the essential difference between a primary and a secondary cell ?*

Ans. In a primary cell, chemical energy is converted into electrical energy and the chemical reactions which take place inside the cell are, in general, *irreversible*. Here the production of energy cannot be increased.

In a secondary cell, the electrical energy is stored during electrolysis as potential energy of the ions which is converted into electrical energy when the current is drawn from the cell. In this case, the chemical reactions which take place inside the cell are *reversible* so that the cell with the same contents can be used over and over again. In the primary cell, the contents are replenished when they get exhausted.

Moreover, from a secondary* cell, electrical energy can be obtained at any desired rate.

40. *What is the principle of a Secondary Cell ?*

Ans. When an elertric current is passed through a voltameter, the electrodes under certain conditions get polarised and a back E.M.F. is produced in it. This makes the voltameter capable of acting temporarily as a voltaic cell until the cause producing polarisation of the plates is removed and the plates regain their original condition.

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* It is portable and handy ; its efficiency is very high and internal resistance very low ; it gives a constant and strong current ; its condition can be judged from the density of its solution.

41. *What is the significance of the word "secondary" used with secondary cells ?*

Ans. Actually, the chief function of these cells is not to supply electric current. If all the components are assembled, they shall not be capable of giving a current in the external circuit, unless, of course, these cells are first charged by connecting them to an external source. Thus, the primary or main function of these cells is to draw current, *while to yield current later on is a secondary function.*

42. *Why should the electrolyte of a lead accumulator be of highest purity ?*

Ans. Any metallic impurity in the acid is likely to be deposited on the plates and cause local action which consumes the plates without giving us any useful energy. An acidic impurity may dissolve the plates uselessly. Water used must also be freshly distilled.

43. *Why should not the electrolyte of a lead accumulator be too strong or too dilute ?*

Ans. If the sulphuric acid is too strong, it tends to convert the plates into lead sulphate even when no current is being taken from it. If the electrolyte is too dilute, the resistance is increased. This is likely to cause buckling or bending of the plates which might lead to short-circuiting. The life of the cell is thus shortended.

44. *How is the electrical capacity of an accumulator reckoned ?*

Ans. The capacity of an accumulator is measured in **ampere-hours** (A.H.). Each ampere-hour is the amount of electricity conveyed by the current of 1 ampere in 1 hour. Thus an accumulator with a capacity of 40 A.H. will provide a steady current of 1 ampere for 40 hours, or a current of 2 amperes for 20 hours and so on. Evidently, the life of an accumulator can be considerably increased by drawing a low current from it.

[**Note** : Two cells of the same E.M.F. may be of different sizes due to their different ampere-hour capacities. The larger cell has larger A.H. capacity.]

45. (*a*) *What is meant by an electrical "short-circuit" ?* (*b*) *When is a cell said to be short circuited ? What is the harm if an accumulator is short-circuited ?*

Ans. (**a**) : An electrical short-circuit is that circuit where the flow of current is bypassed instead of flowing normally. It will blow the fuse because the external resistance will be reduced and the current will increase momentarily, resulting in the break-down.

(**b**) : A cell is said to be short-circuited when its two terminals are joined by a (thick conducting) wire without any other resistance in the external circuit. By doing so the cell is overloaded, *i.e.* an excessive current is drawn from an accumulator. For instance, if the

E.M.F. of the cell be 2 volts and its internal resistance be 0·01 ohm, then, since the external resistance is zero, the current drawn will be $2/0{\cdot}01=200$ amperes. Such a huge current will give rise to enormous heating, resulting in the *buckling* of the plates, disintegration and falling off of the active material. The *capacity*, *efficiency* and *life* of the cell are considerably reduced. If the electrodes are not spoiled, the cell has at least been completely discharged.

46. *How is the accumulator kept in a charged condition on a motor-car ?*

Ans. A dynamo or generator, driven by the engine, delivers current to the accumulator. Thus the current used in starting the engine by the use of the self-starter and in lighting the side, head and tail lamps is replaced.

[**Note** : An automatic electro-magnetic switch placed in the circuit between the dynamo and the accumulator does not allow the current to flow from the accumulator. Therefore the dynamo does not rotate when the dynamo is not charging the accumulator.]

47. *What is the function of making a wire "earth" ?*

Ans. It is a measure of protection. The current will pass away to the earth easily in the event of short-circuiting ; otherwise it will affect the human body in contact with an electrical instrument.

48. *(a) A bird sitting on a naked wire carrying current feels quite safe. (b) Will it make any difference to the bird, if the wire in-between his feet is cut and joined by a long loop of wire, say one kilometre long ? Give reasons.*

Ans (a) : The electric current takes the path of least resistance. In fact in a parallel circuit (*i.e.* shunt), more current passes through the smaller resistance and *vice versa*. The bird and the wire between his feet form two resistances in parallel. The feathery pads of the bird are poor conductors of electricity ; therefore more current passes through the wire and almost nil current passes through the body of the bird. The P.D. across its feet is negligible and the bird feels safe.

(b) : When a long wire is introduced between the feet, its resistance becomes considerable and comparable to the resistance offered by the body of the bird. More current will now pass through the bird and less through the wire. The P.D. between its feet will be considerable and the bird will experience a shock.

49. *Manganin has a high specific resistance while copper has a very low specific resistance. Yet a manganin shunt is preferred in an ammeter. Why is it so ?*

Ans. Use of copper* shunt is objectionable because copper has a high temp. coefficient of resistance. Consequently, when strong currents will flow through the copper shunt, its resistance will undergo a change and thus the calibration of the ammeter will be altered. No such difficulty arises in the use of manganin which has an astonishingly small temp. coefficient of resistance.

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*For making connecting wires, pure copper is used because its sp. resistance is very low and hence it will offer negligibly small resistance to the flow of current. A small quantity of impurities greatly increases its resistance and lowers the conductivity of copper wire

Connecting wires should be *thick*, *short*, *straight* and well insulated.

50. *Why is an ammeter joined in series with the electrical circuit ?*

Ans. Any measuring instrument is connected in an electrical circuit in such a way that it does not alter the current and/or P.D. of the circuit. *An ammeter has a very low resistance* [because a very low resistance shunt has been connected in parallel with the given galv. in order to convert this galv. into an ammeter]. Evidently, its (ammeter's) inclusion in the circuit *in series* will not change the resistance of the circuit and hence the strength of the current (which is to be measured by the ammeter*) in its circuit will not change.

51. *Why is a voltmeter connected in parallel with the electrical circuit ?*

Ans. Any measuring instrument is connected in an electrical circuit in such a way that it does not alter the current and/or P.D. of the circuit. *A voltmeter has a very high resistance* [because a very high resistance has been connected in series with the given galv. in order to convert the galv. into a voltmeter]. A voltmeter is used to measure P.D. between any two points of the electrical circuit. Between these two points, the voltmeter must be connected in parallel so that it draws a very small current from the main circuit. Thus the strength of the current in the part of the circuit, for which P.D is to be measured, remains fairly unaltered and hence the P.D. for this part of the circuit also remains nearly unchanged.

52. *How can you convert your ammeter into a milliammeter ?*

Ans. A milliammeter is a low range ammeter designed to read the thousandth part of an ampere. Evidently, the resistance of a milliammeter will be greater than that of an ammeter and hence to convert an ammeter into a milliammeter, the *resistance of the shunt has to be increased.*

53. *How can a voltmeter measure current in amperes and an ammeter P.D. in volts ?*

Ans. If we pass current through a standard resistance of 1 ohm and measure the P.D. across its ends by a voltmeter, then by using Ohm's Law :

$$C=V/R=V/1=V$$

Thus the value of P.D. is numerically equal to the current in amperes. Similarly the current through one ohm resistance is numerically equal to the P.D. (in volts) between the two ends.

54. *Which do you think a better instrument to measure current—Ammeter or Tangent Galvanometer ?*

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*An *ideal ammeter* should have *zero resistance* while an *ideal voltmeter* should have an *infinite resistance* so that they may not alter the main current.

Ans. Ammeter is a better instrument to measure current since it is more sensitive, reads the strength of current directly in amperes, is dead beat, requires no adjustment, is not affected by external fields and gives same reading at all places.

On the other hand, a Tan. Galv. is less sensitive, does not give current directly, is not dead-beat, requires setting and adjustment, is affected by external fields (even by weak ones), and gives different readings at different places due to variation of H.

55. *If the ammeter was of M.C. type and the magnet in it became weaker with time, what would be the effect on its readings ?*

Ans. Here the resistance of the galv. is not affected, neither that of its shunt. Hence the current C flowing in the M.C. Galv. (converted into an ammeter by applying a shunt) remains same. But

$$C=\frac{T}{H.a.n}.\,\theta$$

Since L.H.S. is constant, its R.H.S. must also remain constant. Since only H in the denominator is decreasing, the deflection (θ) of numerator must also *decrease* proportionately.

56. *Can a moving coil type ammeter measure an alternating current ? If yes, how ? If not, why ?*

Ans. *No.* A moving coil type ammeter cannot measure A.C. This ammeter depends for its action on the magnetic effect of currents, and the direction of the magnetic field produced by the current flowing in the coil depends upon the direction of the current. In an A.C., the direction of the current changes after each half cycle, so the direction of the field due to the coil and consequently its deflection shall undergo a change after each half cycle. The coil, however, can not follow the rapid oscillations of the alternating current, hence it will remain undeflected.

[**Note** : (*i*) A.C. can be measured by a *Hot-Wire Ammeter* in which the scale graduations can not be equidistant since the amount of heat produced is directly proportional to the square of the strength of the current. Thus the distance between consecutive graduations will increase in the ratio of $1^2 : 2^2 : 3^2$......or 1 : 4 . 9 : ......

(*ii*) Hot-Wire Ammeter can measure a D.C. also.

(*iii*) Since the magnitude of A.C. is always changing, an ammeter reads the *Root Mean Square* (R.M.S.) value of the current, which is known as a *virtual ampere.* Its value is $1/\sqrt{2}$ times the value of the maximum current.]

57. *Two cells with the same e.m.f. E and different internal resistances r_1 and r_2 are connected in series to an external resistance R. Under what condition can the P.D. at the terminals of the first cell be zero ?*

Ans. The current C in the circuit is :

$$C=2E/(R+r_1+r_2)$$

$\because$ E.M.F. − P.D. = (main current) × (internal resistance)

$\therefore$ P.D. at the terminals of the first cell is :

$$V_1 = E - C.r_1 = E - 2\times\frac{E\,.\,r_1}{R+r_1+r_2} = \frac{E(R+r_2-r_1)}{R+r_1+r_2}$$

Now $\because$ $V_1 = 0$

$\therefore$ $(R+r_2-r_1)=0$ or $R=r_1-r_2$

58. *Under what conditions can the strength of current in a wire be same for connection in series and connection in parallel of n identical cells ?*

Ans. Let E be the e.m.f. of each cell, r be the internal resistance of each cell, and R the external resistance of the wire.

For connection in series, the current in the external circuit is :

$$C_1 = n.E/(R+n.r) = E/\left(\frac{R}{n}+r\right)$$

For connection in parallel, we have $C_2 = E/\left(R+\frac{r}{n}\right)$

Obviously, if $C_1 = C_2$

Then $\frac{R}{n}+r = R+\frac{r}{n}$; or $R=r$

That is, the resistance of the wire equals the internal resistance of each cell.

59. *Why is Wheatstone bridge so called ?*

Ans. The principle of Wheatstone bridge was discovered by a scientist, Sir Charles Wheatstone. It is called a bridge because the galvanometer circuit forms a kind of *bridge* by connecting two points having the same potential which will be found when there is no deflection in the galvanometer. No electric current flows along this bridge, just like no water flowing over the bridge of a river.

60. *In a Wheatstone bridge (refer Fig. 7.12), $P=Q$ and $R>X$. In what direction will the current flow between B and D ?*

Ans. Positive pole of the cell is connected to A and the same fall of potential exists for ABC and ADC conductors. Since $P=Q$ is given, so for balancing the bridge D should have been placed towards A so that R becomes equal to X and then B and D attain the same potentials. Since fall of potential is proportional to the length of the conductor, so D is at a potential higher than that of B. Evidently the +ve current will flow from D to B or the electrons will flow from B to D.

61. *What do you mean by 'End-error' of a metre bridge ? When is this error positive and when negative ?*

Ans. If the wire used is not exactly one metre long, then the scale may fall short of the wire at the ends or exceed its length. This is called 'end-error'.

The 'end-error' is positive when the metre bridge wire extends beyond the last graduation of the scale and is negative if it is less than the extreme graduation of the scale.

62. *How can you increase the accuracy of your metre bridge ?*

Ans. If we could increase the length of the metre-bridge wire, then the accuracy will be considerably increased because the lengths in the ratio arms will be considerably increased. This is done by having two additional gaps adjacent to the bridge wire in which resistance of known multiples of the bridge wire (10 times or 100 times) may be put - the effect of which will be to increase the effective length of the bridge wire.

63. *Why does a Metre Bridge give more accurate results than a P.O. Box ?*

Ans. In the case of a Metre* Bridge, we shall always get a null point (when galv. shows zero deflection) on the wire because a metre (=100 cm. = 1000 mm.) long wire can be divided into two parts in any ratio—simple, complex or absurd. But in a P.O. Box, we may not get the null point at all for all the available ratios and hence the third decimal place of the unknown resistance is calculated by noting the deflections on both sides of the zero of the scale. Since it is *easier to detect than to read* a deflection, hence the choice goes in favour of a Metre Bridge.

[**Note** : The instrument, called Post Office Box, was first of all used in Post Offices to find out the location where two telegraph wires (of known specific resistance) have got shorted with each other at an unknown distance, by measuring its resistance.]

64. *In the Wheatstone Bridge method, why do we close the battery circuit first and then the galv. circuit ?*

Ans. This procedure is adopted in order to avoid self-induction in the galv. coil. If the glav. circuit is closed before the battery circuit, a temporary current is set up due to self-induction and it flows through the glav. coil in the opposite direction to the main current —thus even at the balance point a momentary deflection will take place.

65. *In the Wheatstone Bridge method, why do we break the galv. circuit first and then the battery circuit ?*

Ans. While breaking the circuit, galv. key is released first and then the battery key. Because if the battery key is released first, induced current at the break will produce a kick in the galv. needle (according to Faraday's Laws of Electro-magnetic Induction). This kick can sometimes break the galv. needle.

66. *Can we use an ammeter or a voltmeter in place of a galvanometer in the Metre Bridge experiment ?*

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*In the metre bridge, *the galv. arm and the battery arm are conjugate* since we can exchange their positions without disturbing the balance point.

Ans. The metre bridge is a practical application of Wheatstone bridge which is essentially a *null* method. In order to locate the position of the null point, we must get deflections (of the needle) on both sides of the zero on the scale. Since ammeter and voltmeter give only *one-sided* deflections, hence they *cannot be used* in place of a galvanometer.

67. *Can we use a Tan. Galv. for finding the position of null point in the metre bridge experiment ?*

Ans. *No* ; it can not be used for the following reasons :

(*i*) it is not very sensitive and therefore it cannot locate the exact position of the null point ;

(*ii*) it is not dead-beat and so its needle keeps on oscillating for a long time before coming to rest ;

(*iii*) it is affected by outside (even weak) magnetic fields or magnetic materials.

68. *Why is a Leclanche cell preferred to a secondary cell while using a Metre Bridge ?*

Ans. Here we require current for a short time only in order to locate the balance point. Moreover, the Leclanche cell does not give strong current like the secondary cell. Hence the wire will not get heated and there will be no error on this account.

69. *Why should the balance point be near the middle point of the Metre Bridge wire ?*

Ans. Let the balance point divide the one-metre long wire of a Metre Bridge in two parts, say l_1 and l_2 cm. (where $l_1+l_2=100$ cm). Since the wire is of uniform diameter, therefore the ratio of their resistances P and Q is given as

$$P/Q=l_1/l_2 \qquad ...(i)$$

In eq. (*i*), we have not taken into consideration the resistance of copper strips fixed at the ends of the wire. Although these copper strips are thick, yet their resistance is not zero. Let the resistance of each copper strip be x. Then we get

$$\frac{P}{Q}=\frac{(\text{resisiance of } l_1 \text{ cm. wire})+x}{(\text{resistance of } l_2 \text{ cm. wire})+x}\neq\frac{l_1}{l_2} \qquad ...(ii)$$

But, if the balance point is at 50 cm. division, then $l_1=l_2=50$ cm. and

$$\frac{P}{Q}=\frac{(\text{resistance of 50 cm. wire})+x}{(\text{resistance of 50 cm. wire})+x}=\frac{l_1}{l_2} \qquad ...(iii)$$

Hence even without measuring the resistance x of copper strips, we are able to eliminate it and thus *accuracy of the result increases* when the balance point* is at (or near) 50 cm. division.

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*Balance point will be near one end of the wire for a very high unknown resistance. If unknown resistance is very small, say of the order of the resistance of the thick copper strip or less, it cannot be determined.

70. *What would happen if the experiment with a P.O. Box is started without introducing any resistance in the ratio arms ?*

Ans. Since $(P+Q)=0$ while $(R+X)$ resistance is joined in parallel to $(P+Q)$ resistance, hence according to the law of resistances in parallel, the effective resistance of the bridge will be zero. Thus the cell will be short-circuited.

71. *What are the least and the greatest resistances that can be measured by a P.O. Box ?*

Ans. We know that for the P.O. Box,

$$\frac{P}{Q}=\frac{R}{X} \quad \text{or } X=\frac{Q}{P}.R$$

(*a*) *For least value of X :*

minimum value of $Q=10$ ohms

" " " $R=1$ ohm

maximum " " $P=10+100+1000=1110$ ohms

$$\therefore \qquad X=\frac{10}{1110}\times 1=\frac{1}{111} \text{ ohm.}$$

(*b*) *For greatest value of X :*

maximum value of $Q=10+100+1000=1110$ ohms.

minimum " " $P=10$ ohms

maximum " " $R=(1+2+2+5+10+20+20+50$
$+100+200+200+500+1000$
$+2000+2000+5000=11110$ ohms

$$\therefore \qquad X=\frac{1110}{10}\times 11110=1233210 \text{ ohms.}$$

72. (*a*) *In a potentiometer, why do we connect the $+ve$ of the battery ond the $+ves$ of the two cells to one terminal ?* (*b*) *Can we connect all the three $-ves$ at that terminal ?*

Ans. (**a**) : This is done in order that the flow of current through the galvanometer due to battery can be *opposed* by the current due to E.M.F. of each of the two cells. Only then a balance point can be obtained.

(**b**) : It makes no difference if all the three negatives are connected together, because even in this case also the battery and each of the two cells will send currents through the galvanometer in opposite directions.

[**Note** : It is always better to get the balance point on the last wire of the potentiometer in order to increase the accuracy in the measurement of lengths. Moreover, the greater length of the wire decreases its potential gradient (*i.e.* fall of potential per cm. length of the wire) which results in increasing the sensitiveness of the potentiometer.]

73. *How is the balance point changed if a resistance is introduced in the (a) Primary circuit, (b) Secondary circuit of a potentiometer ?*

Ans. (**a**) : In this case, the potential gradient will decrease and hence a greater length will be required to balance the E.M.F. of the cell.

(**b**) : No effect on the position of the balance point because at the balance or null point, no current flows through the cell.

74. *(a) What is the difference between E.M.F. and P.D. of a cell ? (b) Which one of these do we measure by a potentiometer and (c) which one of these two terms is used in Ohm's Law ?*

Ans. (**a**) For the difference between these two terms, see Q. 33 above.

(**b**) : We measure E.M.F. and not P.D. with a potentiometer because P.D. is measured on closed circuit while E.M.F. is measured on open circuit. At the balance point in the potentiometer, no current flows through the cell and the cell is therefore considered to be on open circuit.

(**c**) : In Ohm's Law, the term used is P.D. (and not E.M.F. because it does not send any current on open circuit of the cell) because P.D. depends upon the external resistance of the closed circuit.

[**Note** : *A potentiometer is sometimes defined as a voltmeter of infinite resistance.* However small be the current drawn by a voltmeter, the cell in this case can never be called on open circuit. For an exact measurement of E.M.F., the voltmeter should have an infinite resistance—a condition which is impossible to be achieved with an instrument depending for its action or working on the magnetic effect of currents (a voltmeter of infinite resistance will stop giving any reading). A potentiometer does this job very nicely even when the galvanometer shows zero deflection.]

75. *Why should the element of a heater get red-hot while the cable carrying current remains cold ?*

Ans. We know by Joule's Law that the heat produced is directly proportional to the resistance of a conductor when the same current for the same interval of time flows through it. In the given case here, the same current flows through the element as well as through the cable for the same interval of time. But *nichrome* (an alloy of nickel and chromium) is mostly used for the element of the heater. Its resistance is very high and hence heat produced will be more when a current passes through it. On the other hand, the feeding cables (or lead wires) are of copper whose resistance is very low and hence no production of heat occurs when current flows through them.

76. *How does an electric current produce heat ?*

Ans. The flow of electrons in a conductor constitutes an electric current. When a P.D. is applied at the ends of the conductor, these electrons begin to flow. These electrons have to pass through the inter-atomic spaces and in so doing experience some resistance, to overcome which they have to do work which appears in the form of heat in the conductor.

77. *Two heating coils, one of fine wire and the other of thick wire, made of the same material and of the same length, are connected in series to a source of electricity. Which of the coils will produce more heat?*

Which will produce more heat if the coils are connected in parallel?

Ans. We know that for a conductor, its

$$\text{resistance} = (\text{sp. resistance}) \times \frac{\text{length}}{\text{area of cross-section}}$$

Since the two coils are of the same material and of the same length, therefore the thinner wire will have more resistance than the thicker wire. Also, heat produced is directly proportional to the resistance of wire, the time of flow of current and square of the current passing through it.

(*i*) **In series**, since the same current flows through both the wires for the same interval, more heat will be produced in the *thinner wire* than in the thicker wire.

(*ii*) **In the parallel** arrangement of coils, since the same **P.D.** will exist between their terminals, therefore by Joule's Law, the heat produced

$$H = C.V.t/4{\cdot}2 \text{ calories}$$

or

$$H \propto C \text{ when } V \text{ and } t \text{ are constant.}$$

More current flows through the thicker wire than the thinner one, because the currents flowing in the two wires will be in the inverse ratio of their resistanees. Hence more heat will be produced in the *thicker wire.*

78. *A constant P.D. is applied to the ends of a graphite rod, whose resistance decreases with the rise of temp. When will the amount of heat given off by the rod be greater: when it is bare, or when it is covered with asbestos?*

Ans. From Joule's Law, the amount of heat produced by the current in the rod when the P.D. applied to the ends of the rod is constant will equal

$$H = \frac{C.V.t}{4{\cdot}2} = \frac{V^2.t}{\cdot 2\ R} \text{ calories}$$

H will obviously be greater, the lower the resistance R Since asbestos slows down the giving up of heat to the surrounding atmosphere, the rod will be hotter inside the asbestos. But R for graphite falls as the temp rises; therfore H will be greater when the rod is *covered* with asbestos.

79. *A chain of lights is composed of 40 pocket-torch bulbs connected in circuit and supplied from the town grid. After one bulb burns itself out, the remaining 39 bulbs are again connected in series and plugged into the town grid. In which case will the room be more brightly lit, when there are 40 bulbs or only 39 ?*

Ans. At a given P.D. at the ends of a circuit the power available in the circuit equals V^2/R, *i.e.* it is greater, the lower the resistance R. Consequently, in a circuit of 39 bulbs, whose total resistance is less than that of 40, a greater power will be available, therefore the temp. of the heated filaments will be higher and they will give more light. So the room will be more brightly lit from the 39 bulbs than from the 40.

80. *Two electric bulbs, made for 220 volts and 60 watts, one with a metal filament, the other with a carbon one, are connected in series to a circuit of 220 volts. Which of the two filaments will incandensce more ?*

Ans. *The carbon filament will incandensce more.* The reason is that the resistances in carbon and metal filaments depend on temp. in different ways. The resistance of a carbon filament decreases with an increase in temp., while that of a metal filament increases. At normal incandescence, both bulbs have identical resistances (since their power is the same). Therefore when they are connected in series, they incandescence and therefore the temp. of both filaments will be lower than normal—the resistance of the carbon filament will become greater than that of the metal filament. Thus the carbon filament incandensce more (since its fall of potential will be greater).

81. *Why does the brightnees of an electric bulb decrease when an electric heater is smitched on in the circuit ?*

Ans. When an electric heater (or any other appliance) is switched on in the circuit of an electric bulb, two resistances are brought in parallel. Since the same P.D. will exist between their terminals, then by Joule's Law, the heat produced

$$H = C.V.t/4{\cdot}2 \text{ calories.}$$

or

$$H \propto C \text{ when } V \text{ and } t \text{ are constant.}$$

Since the main current C gets divided up, say into C_1 and C_2, for the two paths, the electric bulb's circuit gets less current (C_1 or $C_2 < C$). Hence less heat is produced in the bulb, resulting in decrease of its brightness.

82. *The temp. of the filament of an electric lamp is about 2700°C when it glows. Why is it not burnt up at such a high temp. ?*

Ans. It is because there is no air or oxygen inside it since it is exhausted, while for combustion air or oxygen is a must. In order to prevent volatisation or evaporation of the metal of the filament, it (bulb) is filled with an inert gas like argon or helium. The increase in the pressure of the inert gas on account of increase in its temp. also raises the melting point of the filament material.

[**Note** : Efficiency of a lamp is increased if it has a *coiled-coil filament*. Quantity of light emitted by a straight filament is not sufficient. In coiled-coil lamps, the area of the filament is greatly increased which results in greater efficiency of this type of lamps.]

83. *What is the difference between an incandescent lamp and a mercury-vapour lamp ?*

Ans. In an incandescent lamp, electric current flows through its metallic filament which gets heated and glows. Any inert gas filled in it does not glow at all.

In a mercury-vapour lamp, there is no solid metallic filament. It is rather filled with mercury vapours. The electric current passing through the vapours makes them glow and emit a bluish green light. Here, the consumption of electric power becomes half and hence such lamps are also called *half-watt lamps*.

[**Note** : The mercury-vapour lamp also emits ultraviolet radiations. By coating the glass of the lamp with suitable fluorescent materials which absorb ultraviolet light and re-emit it as visible light, it is possible to obtain light which is nearly white.]

84. (*a*) *What is thermo-electric effect ?* (*b*) *And how can you explain this ?*

Ans. (**a**) : When the two junctions of two *dissimilar* metals are maintained at different temps , an electric current begins to flow in the circuit. These currents are due to absorption of the heat energy and hence this phenomenon is known as thermo-electric effect or *Seebeck-Effect*.

(**b**) : The concentration of electrons at the inter-face in the two materials is not the same, and this results in the transference of electrons from the metal of higher electronic concentration to the other with lower concentration. This gives rise to a contact difference of potential. When one junction is heated relatively to the other, the contact potential at the hot junction is more than that at the cold junction and this difference acts as the resultant E.M.F. which drives the current through the circuit.

85. *What is the direction of current in the thermocouple of copper and iron ?*

Ans. The current in this thermocouple flows from *Copper to Iron* through the *Hot junction* (Fig. 7-19).

[**Note** : To remember this : the symbol of copper is *Cu* and of iron is *Fe*, hence the combination is *Cu-Fe*. Pronounce it as "Coffee" and you will like to take *Hot Coffee*. Hence, remember that the direction of current is from *Cu* to *Fe* through the Hot junction.]

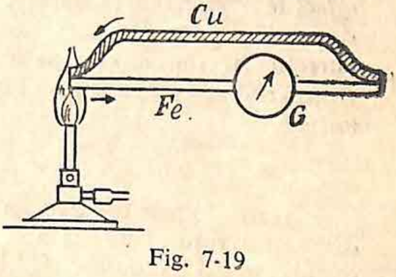

Fig. 7-19

86. *What is the direction of current in the antimony-bismuth combination of a thermocouple ?*

Ans. It is from antimony to bismuth through the cold junction (Fig. 7-20).

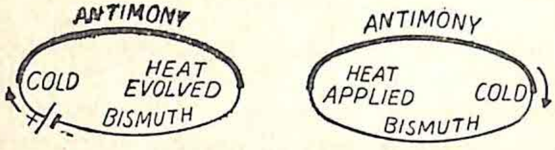

Fig. 7-20

[**Note** : Remember the three letters **ABC**—in this **A** stands for Antimony, **B** stands for Bismuth and **C** stands for Cold. Thus, current flows from antimony to bismuth through the cold junction.]

87. *Is there any change in the current when the temp. of the hot junction is continuously increased in a thermocouple ?*

Ans. *Yes.* If the temp. of the hot junction be continuously increased, the thermo-electric current generated in the thermocouple also increases until a maximum value is reached. After this, it begins to decrease till it becomes zero, and after this temp. the current is reversed.

[**Note** : The temp. of hot junection, for maximum current is known as **Neutral Temp.** for that thermocouple, while the temp. at which the current reverses is called the **Temp. of Inversion.**]

88. *Is the phenomenon of thermo-E.M.F. a reversible effect ?*

Ans. *Yes.* If an electric current be allowed to flow in a thermocouple in the same direction in which thermoelectric current flows, then *heat is absorbed at the hot junction and liberated at the cold junction.* This phenomenon is known as the **Peltier Effect**.

89. *What is the difference between the warmings due to the Peltier effect and the Joule's heating effect ?*

Ans. The heating due to Joule effect depends upon the square of the current ; consequently a reversal of the direction of the current in a circuit has no effect on the heat generated. That is to say, *Joule effect is irreversible in nature.* The Peltier effect, on the other hand, depends upon the direction of the current and a reversal of the current in the circuit reverses the effect from heating to cooling or from cooling to heating. That is to say, *Peltier effect is reversible in nature.*

90. *What is Thomson Effect in a thermocouple ?*

Ans. When the two ends of a conductor are maintained at different temps., there is an E.M.F. acting between different parts of the same conductor. This E.M.F. is due to a temp. gradient existing along the conductor. This phenomenon is known as Thomson Effect.

[**Note** : *In lead, the Thomson Effect is zero.* Lord William Thomson is the same man who is better known in Physics as Lord Kelvin.]

91. *In a plug-type resistance box, why are the plugs and the blocks of the same material ?*

Ans. They are made of the same material (generally of brass) so that no thermo-E.M.F. may develop on account of change of temp. during an experiment. Also if they are of the same material, no change of temp. will occur due to the passage of the current through the plug-block system.

92. *Is there any difference in the mode of conduction of electricity through a liquid and that through a metallic wire ?*

Ans. *Yes*, there is a fundamental difference between the two modes of conduction. In a metallic conductor, free electrons are present which begin to drift as soon as a P.D. is applied at its ends, but there is no movement of the material of which the metallic wire is composed. There is no chemical change in the wire due to the current which, on the other hand, produces heat in it as well as a magnetic field in its neighbourhood.

In a liquid, charged particles—known as ions—are formed. As soon as an electric field is applied between the two electrodes, the oppositely charged ions begin to move in opposite directions. These ions then neutralise on reaching their respective electrodes. This process of conduction of electricity is really equivalent to a transfer of negative charge from the cathode to the anode.

93. *What are ions and how are they produced ?*

Ans. Wherever we dissolve a salt, *e.g.* sodium chloride, in water, it spontaneously dissociates into +vely and −vely charged particles, as Na^+ and Cl^-. These electrically charged particles are known as ions.

Now, sodium atom is neutral. It has one electron in its outermost orbit. In the solution this electron is lost, hence the remainder atom is no longer neutral but exhibits a surplus +ve charge. Similarly, the chlorine atom has one electron less (than the number actually required for saturation of the orbit) in the outer-most orbit. In solution, the neutral atom of chlorine takes up one more electron and converts itself in a −vely charged ion.

94. *What is the difference between an ion and an atom of an element ? Give an example.*

Ans. There is a fundamental difference between an ion and an atom of an element. For instance, in the electrolysis of sodium chloride, sodium ion does not react with water, whereas neutral sodium atom reacts vigorously with water. In the electric field, the sodium ion drifts towards the cathode, strikes against it and picks up an electron from it. Thus, it is converted here in a neutral atom which then reacts with water near the electrode.

[**Note** : The difference between an ion and an atom is also clear from the following : *in the electrolysis of acidulated water, hydrogen is liberated at the negative electrode, but in the Leclanche cell it is the positive electrode which polarises.*]

95. *In electroplating*, gain on cathode equals the loss of weight by anode. But we always prefer to weigh the cathode. Why ?*

Ans. The anode may contain impurities which will also get detached when anode metal gets dissolved in the electrolyte. Hence the loss in weight of the anode will be more than the actual weight of the anode-metal dissolved. On the other hand, pure anode-metal from he electrolyte gets deposited on the cathode and not the impurities. And hence the true weight of the metal deposited becomes known.

96. *If all liquids furnish ions on conduction of electricity through them, then what about mercury which does not furnish any ions ?*

Ans. Mercury is a metal and as such it furnishes free electrons which are responsible for metallic conduction. So here conduction of electricity is not different from that in an ordinary wire.

[**Note** : Distilled water is a bad conductor of electricity. Since no current passes through it, it can not be decomposed or broken into ions. For this purpose, some H_2SO_4 is added to water. Soluble salts also make water conducting.]

97. *A single Daniell cell cannot electrolyse water. Why ?*

Ans. The back E.M.F. of a water voltameter is 1·45 volts while the E.M.F. of a Daniell cell is only 1·08 volts. Hence a single Daniell cell will not be able to electrolyse water.

98. *Tramlines are supplied by direct current. The overhead wire is connected to the positive pole of the dynamo and the rails to the negative pole. Why not the other way about ?*

Ans. The reverse connection would mean that oxygen would be liberated on the rails as a result of electrolysis of the moisture in the track and this would lead to premature corrosion of rails.

99. *A straight permanent magnet falls through a metal ring. Will the magnet fall with the acceleration of a freely falling body ?*

Ans. When a magnet falls through a metallic ring, an induced E.M.F. is developed in it and an induced current flows through the ring. The interaction of the magnetic field of this current and that of the falling magnet are such, according to Lenz's Law, that it hinders or opposes the motion of the magnet which causes the induced E.M.F. Therefore, the magnet's fall will take place with an acceleration that is *less* than that of a free fall.

***Galvanized iron** is prepared by electroplating iron with zinc. **Anodizing** means making the material to be electroplated as anode and then having a coating of its own oxide on it to protect it from corroding.

[**Note** : No electro-magnetic induction will take place if a *non-conducting ring* is employed as it will not be able to change the magnetic lines of force.]

100. *What is a dead-beat galvanometer* ?

Ans. A dead-beat galvanometer is one whose coil does not keep on oscillating for a long time but comes to rest in the deflected position almost instantaneously. Similarly when the current is stopped, the coil returns to its initial position at once.

101. *How is a galvanometer made dead-beat* ?

Ans. A suspended coil type galv. is made dead-beat by winding the coil on a non-magnetic and light metallic frame usually made of aluminium. When the coil is deflected in a magnetic field, the metallic frame cuts magnetic lines of force and induced (eddy) currents are set up in the frame. These currents, according to Lenz's Law, oppose the motion of the coil, whose motion is thus damped and it comes to the position of rest quickly.

102. *When an electric motor running freely, is switched off, it is some time before the armature comes to rest. If, after switching off, its terminals are short-circuited, the armature comes to rest much more quickly. How will you account for this* ?

Ans. When the armature continues to rotate in the magnetic field after switching off the current, induced E.M.F. is produced in the armature. When the terminals of the armature are short-circuited, the induced E.M.F. sends the induced current in the armature. This current, according to Lenz's Law, opposes the motion of the armature —thereby bringing the armature to rest much more quickly.

[**Note** : Similarly we can answer the following : *Why do the oscillations of a freely swinging M.C. Galv. quickly die away when its terminals are short-circuited* ?]

103. *How does Lenz's Law follow from the law of conservation of energy* ?

Ans. According to the law of conservation of energy, induced current or E.M.F. cannot be produced unless some kind of energy is spent in one from or the order.

Lenz's Law states that the direction of the induced current is such that it opposes the very agency which created it. Thus when *N*-pole of a magent is brought near one end of a closed coil, this face of the coil due to the flow of induced current becomes a *N*-pole and thus opposes the motion of the approaching *N*-pole. Evidently, mechanical work has to be done against this force of repulsion between two *N*-poles. Similarly, on withdrawing *N*-pole, the nearer face of the coil on account of the induced current becomes a *S*-pole which opposes the withdrawal of the *N*-pole. Some mechanical work has to be done against this force of attraction between opposite poles. It is this mechanical work that is converted into electrical energy which is neither created nor destroyed. Thus Lenz's Law follows from the law of conservation of energy.

104. *What is the difference between an Induction Coil and a Transformer ?*

Ans.

	Induction Coil	*Transformer*
(*i*)	It works with D.C.	It works with A.C.
(*ii*)	It gives an intermittent unidirectional (D.C.) current.	It gives a continuous A.C.
(*iii*)	It can only step-up the applied voltage.	It can be made as desired—step-up or step-down.
(*iv*)	It has a straight (soft-iron) core.	It has a closed (soft-iron) core, resulting in greater efficiency.

105. *Why are some transformers very large and others small ?*

Ans. Although it is the number of turns which determines the step-up of a transformer, a greater *quantity* (amperage) of current requires thicker wire through which to flow without overheating. Hence, the transformers handling many thousands of amperes are both large and usually water- or oil-cooled.

106. *Why is a humming sound produced when a transformer is placed on a sheet of iron ?*

Ans. The rapidly increasing and decreasing magnetism of the core of transformer makes the iron sheet vibrate and a humming sound is heard.

107. *In a step-up transformer, a high voltage is obtained by supplying a low A.C. voltage. Does it not contradict the principle of conservation of energy ?*

Ans. It does not contradict the principle of conservation of energy. Let V_p and V_s be the voltages and C_p and C_s the currents in the primary coil and secondary coil of a transformer. Since the current and voltage in any coil of a transformer are inversely proportional to each other, so

$$V_p.C_p=V_s.C_s$$

In the given time t,

$$V_p.C_p.t=V_s.C_s.t$$

or (wattage in P. coil) × t = (wattage in S. coil) × t

or input = output

108. *Why are such enormously high A.C. voltages used in the overhead grid electrical distribution systems ?*

Ans. A.C. is used when long distances have to be traversed by conductors, owing to the drop in voltage being so excessive under the same conditions with D C. For example, if a supply at 100 volts were fed into a cable of equal cross section throughout its length of say, 100 km., possibly only 1 volt would be available at the far end of the cable. This could be overcome by proportionately increasing the cross-section of the cable as the distance from the supply increases but this would be both unwieldy and colossally expensive.

To avoid this difficulty, A.C. at about 133000 volts is fed into the grid. And after travelling at high voltage and proportionately low amperage (so that heat produced is also reduced) on its long journey through wires of moderate thickness, it is again rendered at the far end by transformers to 240 — 480 volts for domestic use.

109. *Does the human body generate electricity ?*

Ans. *Yes.* The generation of electricity is one of the properties of a living cell inside the body. Due to the numerous chemical reactions taking place within the (human or animal) body, there exists always a P.D. between the interior of every living cell and the outside world. This current continually varies according to any injury of the living cell or to the action made.

110. *When wiring for lighting is installed in a house using A.C. from a three-phase circuit, two wires are used : 'neutral' and 'phase'. It is not allowed to fit fuse plugs to both wires ; fuse plug is put on only one, the 'phase' wire. Why ?*

Ans. If fuse plugs were put on both wires, overloading might cause the fuse to burn out on the neutral (or earth) wire, but not on the phase (or live) wire. Then the light would go out, but the whole wiring system would be under pressure relative to the earth. This will give a severe shock, if the wiring is handled carelessly.

111. *A condenser is used in (i) an A.C. circuit, (ii) a D.C. circuit. What will be the difference in its behaviour ?*

Ans. **(i)** : In an A.C. circuit containing a condenser, the current will be constantly flowing. Here in the first half cycle, the electrons are transferred from one coating of the condenser to the other and the condenser is charged. In the next half cycle, the E.M.F. changes sign, hence the electrons are re-transferred from the later coating to the former one and the condenser is now charged in the reverse direction.

(ii) : In a D.C. circuit, there will be a momentary flow of charge, which will stop as soon the condenser is charged. Thus, there will be no continuous flow of current as in an A C. circuit.

112. *What do you understand by "Back E.M.F. of an Electric Motor" ?*

Ans. As the armature starts rotating within the poles of field-magnets of an electric motor, there is change in the magnetic flux traversing the armature and hence an induced E.M.F. is set up which opposes (Lenz's law) the applied E.M.F. This is called the back E.M.F. of the motor and its strength goes on increasing as the speed of rotation of motor is increased till at a particular speed the back E.M.F. becomes nearly equal to the applied E.M.F. - so that the net current flowing through the armature coil is very small.

[**Note** : (*i*) At the start when the current is switched on, there is no induced E.M.F. and hence if full voltage is applied at once, the large current flowing through the armature coils may burn them. That is why the **starting switch of the motor** offers a high resistance to the current in the beginning and this resistance is gradually cut off as the motor gains speed. After this the induced back E.M F. keeps the net current low.

(*ii*) *Efficiency of an electric motor* is less than 100% on account of heat produced in the coil, friction between its movable parts and eddy currents produced in its soft iron armature.]

113. *How are two distinct messages sent through one Telegraph circuit in the same direction ?*

Ans. The instruments employed work only with currents in one given direction and for this purpose they are polarised or permanently magnetised so that they respond to currents of a given direction electrically. By using two such polarised receiving relays, of opposite polarisation, two sets of signals sent with opposite polarity will be automatically sorted out at the receiving end, neither conflicting with its fellow traveller.

114. *In a telephone receiver, why are the coils wound around a permanent magnet ?*

Ans. It is done so as to correctly *reproduce the frequency* of the signal coming from the transmitting station.

If a soft iron core is used, the diaphragm of the receiver would vibrate with twice the frequency of the incoming signal. This will result in the increased shrillness which is most annoying to the listener.

115. *Why is earth not used to complete the telephone circuit as is done in telegraphy ?*

Ans. The reason is that the induced currents which make the diaphragm of the receiver vibrate are *very weak* and will be easily disturbed by other stray currents passing through the earth or through cables embedded in the earth and the receiver will give only noises, not clear sounds.

116. *How is sound transmitted over the telephone ?*

Ans. Upon lifting the telepone, an electric current flows in both the transmitter and the receiver. The transmitter is a microphone with an aluminium diaphragm which vibrates in unison with the speaker's voice. Attached to the diaphragm's centre is a "button" filled with compressed carbon granules. Vibrations of diaphragm vary the degree of compression causing the resistance of the granules to fluctuate. Thus fluctuating currents are set up and these electrical reproductions of sound waves are conveyed by the line wires to the distant listener, whose receiver contains a small electro-magnet which vibrates in sympathy with the pulsating currents and converts them into sound.

117. *Why do not telephone currents moving simultaneously in opposite directions in the same line wires cancel each other ?*

Ans. In a telephone circuit, sound waves are converted into fluctuating currents which flow in the line wires to reach the telephone receiver. Since the same line wires are simultaneously used and telephone messages are carried in opposite directions, yet these currents are unable to cancel one another because these currents are **polarised** and flow in different planes inclined to one another. The polarised currents cannot interfere with one another unless they are in the same plane.

118. *Why do the electrons constituting cathode rays not stop their journey at the anode ?*

Ans. The greater the potential to which the anode is raised, the greater will be the speed of the electron stream. Consequently, with a sufficiently high anode potential, those electrons with the greatest speed will pass by the attractive field of the anode, and passing through the hole therein, travel in straight lines till they hit the prepared wall of the tube, being then visible as light or fluorescence.

[**Note** : (*i*) Consisting of —vely charged electrons, the cathode rays are deflected by magnetic and electric fields.

(*ii*) Stream of cathode rays can be focussed to a pencil of rays by surrounding the emitting filament with a negatively charged metal cylinder.]

119. *State the points of difference between X-rays and Cathode-rays ?*

Ans. (*i*) X-rays are electro-magnetic waves like light while cathode rays are —vely charged particles.

(*ii*) X-rays can not be deflected by electric and magnetic fields while cathode rays are deflected by both the fields.

(*iii*) X-rays travel with the velocity of light while cathode rays travel with 1/10th of the velocity of light.

(*iv*) X-rays have a large penetrating power while cathode rays have no such power.

120. *If the tube of a neon-lamp is wiped, it can be seen to gleam for a short period. Why ?*

Ans. For the gas in a neon lamp to shine, an electric field must be created on it. As a result of the friction on the glass tube of the neon lamp, electric charges appear and their field causes a brief fluorescence of the lamp.

121. *In radioactivity, of what does the disintegration of uranium consist ?*

Ans. When an individual atom of uranium disintegrates, an "alpha" particle consisting of helium nucleus is expelled with great energy of motion, and the remaining heavy atom is different in its properties from the original uranium atom, though it is still radioactive. A succession of spontaneous disintegrations takes place, during which eight alpha particles and six beta-particles are emitted, after which the originally unstable uranium atom becomes stable being turned into an atom of lead. [For this process, about 6·5 million years would be required].

122. *Explain the changes in the structure of an atom which result from the release or emission of (a) an electron, (b) an alpha-particle, (c) a beta-particle.*

Ans. (**a**) An **electron** carries one unit of negative charge and its mass is considered as zero. Number of orbital electrons equals the number of protons (each carrying a +ve charge equal in magnitude to that of an electron charge) in the nucleus whose remaining weight is completed by neutrons. For any element, its

atomic number = no. of protons in its nucleus

and atomic weight = no. of protons + neutrons in its nucleus

When an atom loses one of its orbital* electrons, its atomic number and atomic weight both remain same. But the atom as a whole stays +vely charged. Soon it will capture an electron from somewhere and will once again become neutral.

(**b**) : An **alpha-particle** is a nucleus of a helium atom and lacks the two orbital electrons. Thus its weight is 4 units and it carries 2 units of +ve charge as it has 2 protons. The particle is ejected from a radioactive atom and will definitely change the nucleus of the remaining atom whose atomic number will be reduced by 2 and atomic weight by 4. Evidently, it will now have 2 extra orbital electrons.

(**c**) **A beta-particle** is also ejected from the nucleus. Its mass is zero and carries – ve charge equal to that of an electron. This will convert a neutron (${}_0n^1$) into proton (${}_1p^1$) as below :

$${}_0n^1 = {}_{-1}\beta^0 + {}_1p^1$$

Thus the atomic weight of the nucleus** remains same but its atomic number is increased by 1.

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* A revolving electron in any orbit possesses a definite quantity of energy and therefore these orbits are called '**Energy Levels**'. The farther an electron is from the nucleus, the greater is the energy associated with it.

** **Nucleons** : Since in the structure of the atom, protons and neutrons are found only in the nucleus, they are called nucleons

Nuclide : Any particular nuclear species, distinguished by specific values of both atomic number and atomic weight, is called a nuclide. Nuclides having the same atomic number are called *isotopes* while those having the same atomic weight are called *isobars*.

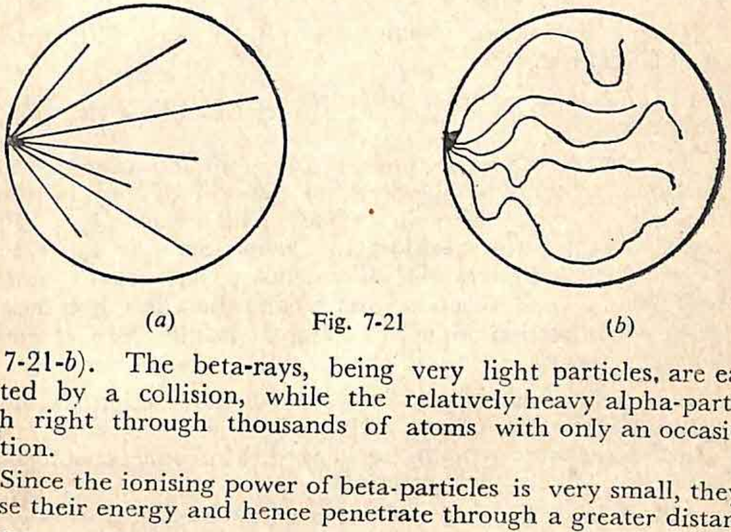
Triton : The ${}_1H^3$ isotope of hydrogen is called "tritium" and a triton is a nucleus of a tritium atom.

123. *How will you justify the fact that beta-particles, which usually possess higher velocity but lower energy than alpha-particles, also possess a longer range of penetration in air than alpha-particles ?*

Ans. Mass of a beta-particle is 1/1836 of the mass of a proton while that of an alpha-particle equals the mass of 4 protons. Velocity of beta-particles is upto 99% of velocity of light while it is just from 1% to 10% of the velocity of light for alpha-particles. Evidently, alpha-particles will possess greater kinetic energy.

When an alpha-particle speeds through matter, it picks up and loses 2 electrons at a rapid rate. At each collision, some of its kinetic energy is used in ionizing the atom encountered while giving that same atom certain amount of kinetic energey. Since alpha-particles produce the greatest number of ions in a given path, they penetrate a smaller distance and therefore have a poor penetrating power.

In a cloud chamber, we notice that the alpha-ray tracks are straight (Fig. 7-21-*a*), whereas the beta-ray tracks are crooked (Fig. 7-21-*b*). The beta-rays, being very light particles, are easily deflected by a collision, while the relatively heavy alpha-particles plough right through thousands of atoms with only an occasional deflection.


(*a*) Fig. 7-21 (*b*)

Since the ionising power of beta-particles is very small, they do not lose their energy and hence penetrate through a greater distance.

[**Note** : (*i*) Any type of clothing is a sufficient protection against α-rays. A thick closely woven garment absorbs a considerable part of β-rays. But γ-rays have a very high penetrating power. But the strongest biological effect is produced by those rays that ionize most heavily. The most ionizing are α-rays, then come β-rays and last γ-rays. (*ii*) Relative ionizing powers of these three types of rays are inversely proportional to their penetrating powers.]

124. *What happens when an atom carries an electric charge ?*

Ans. It behaves as though it has an extra weight. It is on account of its velocity or **K.E.**

125. *What holds the protons and neutrons together in the nucleus ?*

Ans. The binding energy is due to the fact that the total mass of the protons plus the total mass of the neutrons in the nucleus is *greater* than the resultant mass of the nucleus. This loss in mass is equivalent to an amount of liberated energy, which is just the amount of energy binding together the nucleus.

126. *What is nuclear fission?*

Ans. It is a process of breaking (fission) the **nucleus** of a heavy atom with the help of neutrons. The difference in the masses of the parent nucleus and the sub-nuclei thus produced results in the liberation of a vast amount of energy. The material which can be split is called fissionable material, *e.g.* U^{235}. This is used in uranium bombs.

Fission is done by bombarding slow-moving neutrons on the nucleus of, *e.g.*, U^{235}. It sets free some of the neutrons which were inside the nucleus. These neutrons now again smash the nucleus and *chain-reaction* occurs with a high speed inside the bomb material. This releases a very large amount of energy called *nuclear energy.*

[**Note** : For chain reaction, a critical mass of the fissionable material is required.]

127. *Explain in what ways the nuclear energy is different from the chemical energy.*

Ans. When the nucleus of a heavy atom, *e.g.* uranium, disintegrates, nuclear energy is liberated on account of conversion of mass into energy, obeying Einstein's equation $E=m.c^2$ where E is the energy in ergs, m is the mass lost in grams and c is the velocity of light $(=3\times10^{10})$ in cm./sec. Tremendous amount of energy is evolved when a chain reaction occurs and the effect becomes cumulative on the liberation of nuclear energy. Radioactive elements are used for this purpose.

In the chemical energy, there is no chain reaction and no transformation of mass into energy. Hence it is not very large. The total mass of the substance remains unchanged. Moreover, chemical energy is liberated by all chemical reactions.

128. *What is an electron-volt?*

Ans. Electron-volt (abbreviated as eV) is the unit in which the energy of single atomic particles is measured. It is the *energy acquired by an electron in falling throngh a P.D. of 1 volt.*

[**Note** : (*i*) An electron with an energy of 1 eV has a speed of 580 km./sec. A proton with an energy of 1 eV has a speed of only 13·5 km./sec. since its **mass** is 1840 times that of the electron.

(*ii*) When coal is burnt, the energy released per atom is about 4 eV. When uranium undergoes fission, the enery liberated is stupendous—about 200 million eV (written as 200 M eV) per atom. That is why uranium was utilised in atom bombs. Uranium is found in nature. It has now been replaced by plutonium which is artificially prepared from uranium.

(*iii*) **Quantum** is the name given to a packet of radiant energy $=h.\nu$ joules$=\dfrac{h.\nu}{1{\cdot}6\times10^{-19}}$ eV where h is Planck's constant and ν is the frequency of the radiation. An alternative name usually used when light energy is being considered is **photon**.]

129. *How can the age of earth be determined ?*

Ans. It is possible to make an estimate of the age of earth's crust by considering the rate at which radioactive elements break down into inert elements. A number of methods are now available, the most important being those based on the study of abundances of isotopes of lead and other elements. From the data obtained, estimates could be made of the following points on the time scale :

(1) Age of earth's crust=5300 million years. As a planet, earth has existed for several thousand million years.

(2) Life emerged about 200 million years ago.

(3) First large scale occurrence of fossils=120 million years ago. It is estimated that the earth is about 6,000,000,000 years old.

130. *"Sun is likely to retain its present amount of energy for millions of years to come". Comment upon this statement.*

Ans. Many theories have been put forward for the enormous output of energy by the sun :

(*a*) Radioactive substances, like radium, in the sun disintegrate and give out the great amount of energy it throws out.

(*b*) Changes are continuously taking place in the sun's material. The sun, due to extremely high temp. in its interior, acts like a huge cyclotron smashing the hydrogen atoms which turn into helium with the release of enormous energy. And since the sun has lots of hydrogen in it, this process will go on for millions of years and hence the sun will keep its output of this energy.

(*c*) A certain amount of heat must also be due to the contraction of sun's material, since the contraction of gases leads to rise in temp.

All these factors share in maintaining this constant stream of radiant heat and light given out by the sun.

131. *What is the chief value of Applied Physics ?*

Ans. The chief value of Applied Physics stands for :

(*a*) putting science in the service of man ;

(*b*) uplifting the standard of mankind by improving their living conditions ; and

(*c*) making the life comfortable and easy-going.

"*Nothing is good or bad but thinking makes it so*". It is we who have used science more for the destructive side (*i.e.* war) than for the constructive side (*i.e.* peace). A little fire can help us in cooking food, protect us from the winter, etc. if used properly ; otherwise $\frac{1}{10}$th of the same fire can burn the whole house or the whole locality in seconds. This all depends on us how we utilise the services of science. *It is a good servant but a bad master.*

1. *Conductance* is the reciprocal of resistance.
2. *Coulometer* is another name for a voltameter.
3. *Dosimeter* is a device to measure total exposure to radioactive radiations.
4. *Dynamo* is an electric generator in which electromagnets fed with D.C. are employed to provide the magnetic field.
5. *Magneto* is an electric generator in which permanent magnets are employed to provide the magnetic field.
6. *Resistor* is another name for resistance (in reality for the resistance-offering conductor).
7. *Resistivity* is another name for specific resistance.
8. *Toroid* is a long solenoid wound on a ring.

Answers

CHAPTER I

I. (1) Length, Mass and Time. (2) five
(3) cm., ft., gm., lb. and sec. (4) pitch
(5) least count. (6) Pierre Vernier (7) small ; screw.
(8) radius of curvature of spherical surfaces :
(9) reciprocal (10) zero. (11) infinite. (12) zero.
(13) matter and energy. (14) matter.
(15) Diamond (16) Hydrogen

II. (1) Metre rod. (2) Vernier Callipers.
(3) Screw Gauge. (4) Spherometer (5) Burette.

III. (1) molecule. (2) matter (3) surface tension.
(4) adhesion. (6) cohesion. (6) ductile.
(7) *a* (8) *a* (9) *b* (10) *a*

IV. (1) *f* (2) *d* (3) *a* (4) *c* (5) *e* (6) *b*

CHAPTER II

I. (1) change ; position (2) rate ; change
(3) rate ; change (4) magnitude ; direction.
(5) zero. (6) uniform (7) velocity (8) acceleration
(9) motion ; mass ; velocity. (10) metres/sec^2 ; cm./sec^2
(11) zero. (12) 40 cm./sec.
(13) retardation/deceleration (14) bus.

II. (1) *b* (2) *a* (3) *a* (4) *b* (5) *b*, c (6) *b*
(7) *a* (8) *c* (9) *a* (10) *d* (11) *d* (12) *d* (13) *c*

III. (1), (3), (5), (6), (8), (10) and (11) are correct.

CHAPTER III

I. (1) inclined to each other at an angle of 90°.
(2) Parallelogram/Triangle of Velocities.
(3) straight line ; parabola (4) equal to
(5) Parallelogram Law or Triangle Law of Velocities.

(6) Polygon Law of Velocities. (7) $v^2+2.u.v \cos\theta$
(8) $\dfrac{v.\sin\theta}{u+v.\cos\theta}$ (9) $\sqrt{u^2+v^3}$ (10) $u.\sqrt{3}$
(11) 90°

II. (1) *b* (2) *b* (3) *c* (4) *c* (5) *d* (6) *b*
(7) *b* (8) *a*

CHAPTER IV

I. (1) backwards (2) forward
(3) due to attraction of body (4) 32
(5) newton. (6) m_2u_2 ; m_2v_2
(7) force × time ; $m(v-u)$. (8) 9·80
(9) quantity of motion (10) inertia.

II. (1) matter ; opposes any change. (2) Momentum ; motion.
(3) acceleration ; mass. (4) action ; equal ; reaction.
(5) definition (6) measured. (7) are
(8) is (9) equal (10) easier (11) easy
(12) 3rd (13) 3rd (14) vector (15) 1st

III. (1) *a* (2) *c* (3) *b* (4) *f* (5) *c* (6) *c*
(7) *e* (8) *b* (9) *c* (10) *c* (11) *d* (12) *c*
(13) *d* (14) *a*, *b*, *c* (15) *a*, *b* (16) *d* (17) *b*, *c*
(18) *a* (19) *c* (20) *c* (21) *c* (22) *c*

IV. (1) *e* (2) *c* (3) *d* (4) *b* (5) *a*

CHAPTER V

I. (1) uniform ; variable (2) decreases. (3) centrifugal
(4) tangentially to the grinding stone. (5) inwards.
(6) centripetal (7) away from (8) towards

II. (1) *c* (2) *b* (3) *c* (4) *c* (5) *d* (6) *a*

III. (2), (3), (5), (8), (11), (13) and (14) are correct.

CHAPTER VI

I. (1) gravity. (2) does not depend (3) *g*
(4) its length (5) decreased. (6) decreases.
(7) increase (8) 2 (9) more (10) simple pendulum.
(11) physical ; spring (12) mass
(13) earth (14) same or constant

II. (1) attraction (2) product (3) square ; their centres.
(4) equal (5) larger (6) exactly equal (7) *a*
(8) Copernicus (9) decrease (10) increase (11) increase
(12) slow (13) $\sqrt{2}$ (14) fast (15) heavier

III. (1) *d* (2) *b* (3) *b* (4) *b*, *d* (5) *b*, *d* (6) *b*
(7) *c* (8) *a*, *f*, *g* (9) *a*, *c* (10) *b* (11) *d* (12) *b*, *c*
(13) *a*, *e* (14) *d* (15) *b* (16) *d* (17) *b* (18) *d*

IV. (1) *c* (2) *e* (3) *d* (4) *a* (5) *b*

CHAPTER VII

I. (1) Erg (2) work ; M.K.S. (3) one (4) 746
(5) position or distortion (6) motion (7) kinetic
(8) potential (9) energy ; power. (10) $1000 \times 60 \times 60$
(11) 9·8 (12) potential (13) potential

II. (1) power. (2) work, eneagy. (3) momentum.
(4) work. (5) Power (6) P.E.
(7) remains constant (8) equal to
(9) 125 ft. pdls. (10) 1960000 ergs. (11) *b*, *d*, *c*, *e*, *f*, *a*
(12) *a*, *d* (13) *a* (14) *c* (15) *d* (16) *d*

CHAPTER VIII

I. (1) more (2) self ; force. (3) limiting friction.
(4) normal reaction.
(5) μ (*i.e.* the coefficient of friction).
(6) irregularities in the surfaces in contact.
(7) lubricants.
(8) the force of limiting friction to the normal reaction.
(9) evil. (10) it opposes the motion.
(11) area of the surfaces in contact ; nature and physical states of the surfaces.
(12) R (*i.e.* normal reaction) ; R.

II. (1) no independent (2) less than (3) normal reaction
(4) is independent of (5) directly (6) opposite
(7) *b* (8) *d*, *e* ; *d*, *f* ; *e*, *g* ; *f*, *g*.
(9) independent of (10) better (11) better (12) can not

III. (1) *d* (2) *g* (3) *a* (4) *b* (5) *c*

CHAPTER IX

I. (1) remains the same (2) translation.
(3) rotation. (4) moment.
(5) length of perpendicular drawn from the axis of rotation to the line of action of the force.
(6) couple. (7) anticlockwise ; clockwise
(8) sum of clockwise moments=sum of anticlockwise moments
(9) equilibrium. (10) zero. (11) centre of gravity.
(12) lowering (13) neutral

II. (1) large. (2) lowered. (3) less easily.
(4) forward. (5) outside (6) identical.
(7) vector (8) within (9) outside

III. (1) *a* (2) *a* (3) *a* (4) *b* (5) *b* (6) *b*

IV. (3), (4), (5), (6), (7), (8), (9), (10) and (11) are correct.

CHAPTER X

I. (1) load lifted or resistance overcome ; effort applied.
(2) effort ; load. (3) output ; input. (4) Velocity Ratio.
(5) greater (6) $\frac{2\pi R}{h}$ (7) $\frac{\text{radius of wheel}}{\text{radius of axle}}$
(8) $\frac{2R}{R-r}$ (9) $\frac{1}{2.\sin(\theta/2)}$ (10) one
(11) direction (12) distance or speed. (13) sensitive.
(14) between the fulcrum and the effort. (15) 2 ; 1.

II. (1) 1 (2) V.R. (3) more than (4) 1st (5) 2nd
(6) 3rd (7) 2nd (8) 1st (9) 2nd (10) 3rd
(11) 3rd (12) 3rd (13) easier (14) 1 (15) *b*

III. (2), (4), (6), (7), (8) and (9) are correct.

CHAPTER XI

I. (1) deforming forces (2) restoring (3) shearing strain
(4) no (5) dyne/sq. cm. (6) dyne/sq. cm.
(7) shearing stress (8) contract. (9) capillaries.
(10) capillarity. (11) acts as a capillary tube.
(12) capillaries (13) concave ; convex.
(14) horizontal. (15) raised ; depressed.
(16) zero. (17) cohesion ; adhesion.

(18) the molecules of water and glass ; the water molecules.
(19) faster (20) vary

II. (1) directly proportional (2) steel.
(3) $\frac{F.L}{A.l}$ (4) $\frac{F}{a.\theta}$ (5) $\frac{p.V}{v}$
(6) decreases (7) decreases (8) depends

III. (1) *c* (2) *b* (3) *a* (4) *b* (5) *c* (6) *a*
(7) *c* (8) *d* (9) *b* (10) *a* (11) *c* (12) *b*

IV. (1) Elastic fatigue. (2) Yield point.
(3) Permanent set. (4) Tensile strength.
(5) Viscosity. (6) Streamline motion.
(7) Turbulent motion. (8) Bernoulli's Principle.

CHAPTER XII

I. (1) pressure. (2) depth ; quantity (3) normal
(4) same (5) h ; g. (6) artesian
(7) upthrust.
(8) its wt. is less than the wt. of the air displaced by it.
(9) Principle of Transmission of Fluid Pressure.
(10) area of pump plunger ; (radius of pump plunger)^2
(11) Hydrostatic paradox. (12) reach (13) above

II. (1) lighter (2) lighter (3) rises higher. (4) more
(5) lighter (6) thin (7) large (8) float.
(9) need not be (10) is

III. (1) *b* (2) *a* (3) *c* (4) *c* (5) *b* (6) *b*

IV. (1), (2), (3), (4), (5) and (6) are correct.

CHAPTER XIII

I. (1) atmospheric (2) Aneroid (3) 76 cm. of Hg.
(4) more (5) Altimeter.
(6) Torricellian vacuum. (7) increases
(8) all constant temps. (9) one
(10) measuring pressure of gases or vapours. (11) perfect

II. (1) outwards ; inwards. (2) shorter (3) cannot
(4) rain (5) does not affect
(6) not affected (7) same (8) less
(9) Delhi. (10) Aneroid

III. (1) *c* (2) *d* (3) *b* (4) *c* (5) *b* (6) *b*
(7) *b* (8) *c* (9) *c* (10) *b* (11) *c*

IV. (2), (3), (5), (7) and (9) are correct.

V. (1) *c* (2) *a* (3) *d* (4) *b* (5) *f* (6) *e*

CHAPTER XIV

For this purpose, read "Concise Mechanics" thoroughly.

CHAPTER XV

I. (1) energy. (2) mechanical (or frictional) energy. (3) sun.
(4) sun. (5) earth. (6) sun. (7) nuclear
(8) degree (9) temp. (10) higher ; lower temp.
(11) 36·9 (12) Centigrade (13) cause-and-effect
(14) a Maximum and Minimum Thermometer.
(15) pure ice melts at 76 cm. pressure.
(16) pure water boils at 76 cm. pressure.
(17) the distance between its two fixed points is divided into 100 (centi) degrees or equal parts.
(18) it was divised by Fahrenheit. (19) fine ; large
(20) fundamental.

II. (1) heat. (2) temp. (3) quality of heat.
(4) cannot be (5) calorimeter. (6) as much as
(7) $-273°C$. (8) $-39°C$. (9) $-130°C$. (10) $35·7°C$.
(11) $78°C$. (12) lower (13) lower (14) *b* (15) *a*
(16) *b* (17) momentum (18) temp. remains same in all cases.

III. (1) *c* (2) *d* (3) *e* (4) *a* (5) *a*

CHAPTER XVI

I. (1) expand ; contract (2) more (3) as much a s
(4) light (5) smaller (6) slow ; fast
(7) 3 times (8) cold (9) hot
(10) inverse (11) a compound bar.
(12) different (13) same (14) less
(15) 7 times more (16) $4°C$. (17) 1/273.
(18) less (19) zero.
(20) 4·15 joules/gm./$°C$=1 calorie nearly.
(21) 8·3 joules/gm. mol./$°C$=2 calories nearly.
(22) 22·4 litres. (23) 1·293

II. (1) increase. (2) *b* (3) second
(4) *c* (5) larger (6) less (7) increases
(8) surface. (9) increases. (10) negative.
(11) around the edges ; in the middle. (12) *a*
(13) raised (14) loose (15) ideal

(16) gas (17) 100°K or $-173°C$.

(18) *d* (19) *d* (20) *d*

III. (1) *f* (2) *a* (3) *f* (4) *e*

(5) *b* (6) *d* (7) *a* (8) *c*

IV. (1) *f* (2) *e* (3) *a* (4) *c*

(5) *b* (6) *d*

CHAPTER XVII

I. (1) mass, sp. heat and temp. (2) mass, sp. heat and fall of temp.

(3) calorie and kilocalorie. (4) B. Th. U. and therm.

(5) 1 gm. water : 1°C. (6) 1000 lb. water ; 100°F.

(7) 1 gm. ; 1°C (8) thermal capacity.

(9) sp. heat (10) less (11) more

(12) Bomb's calorimeter. (13) kilocalorie and therm.

(14) less (15) numerically equal

(16) logarithmic spiral.

II. (1) 252 (2) *c* (3) conduction. (4) radiation.

(5) *c* (6) high. (7) low. (8) *c* (9) *a*

(10) negative. (11) decreases (12) increases (13) ×

(14) same (15) rates of loss of heat (16) small.

(17) *d* (18) is not (19) *A* (20) *D*

III. (1) Water equivalent. (2) Thermal capacity.

(3) Solar constant. (4) Law of mixtures.

(5) Calorimetry. (6) Hypsometry.

(7) Cooling constant.

CHAPTER XVIII

I. (1) Melting or fusion, and freezing or solidification.

(2) Vaporisation, and condensation or liquefaction.

(3) Sublimation. (4) Latent heat.

(5) L.H. of fusion. (6) L.H. of vaporisation.

(7) Regelation. (8) Freezing mixture.

(9) Ice calorimeter. (10) Saturated vapours.

(11) Saturated vapours. (12) Saturated vapours.

(13) Evaporation. (14) Steam calorimeter.

(15) Boiling point.

II. (1) raised (2) lowered (3) raised

(4) decreases. (5) increases (6) raised

(7) vacuum pans (8) higher (9) decreases

(10) high (11) zero. (12) 1670

(13) 0·091 (14) critical temp.

III. (1) lower (2) less readily (3) more difficult
(4) water. (5) unlikely (6) remains unaltered
(7) increases (8) decreases (9) lower than
(10) increases. (11) less dense than
(12) approximately. (13) approximately. (14) same
(15) raise (16) does not cook (17) more
(18) lower (19) *a*, *c* (20) higher than

IV. (1) Ice under pressure melts and refreezes on removing the pressure.
(2) Ice melts when subjected to pressure.
(3) One gram of ice on melting decreases in volume by 0·091 c.c. and requires 80 calories of heat.
(4) Cooling is caused by evaporation.
(5) Temp. of freezing mixture is lower than that of ice.
(6) Cooling is caused by evaporation.
(7) Boiling point of water (or any liquid) is raised by the increase of pressure.

CHAPTER XIX

I. (1) 1 cu. metre of air. (2) sat. vap. pressure at that temp.
(3) R. H. ; A.H. (4) sat. vap. pressure at room temp.
(5) just sufficient to saturate it. (6) room temp.
(7) 100% nearly. (8) zero. (9) air or dust particles.
(10) fog. (11) frozen dew.
(12) equals actual (unsaturated) vapour pressure at room temp.
(13) equal to external (or atmospheric) pressure.

II. (1) Hygrometer (2) less dense than (3) dryness
(4) decreases (5) decreased. (6) retards
(7) cloudy. (8) windy. (9) high.
(10) conductors (11) near the ground. (12) raised
(13) not formed (14) low. (15) increases
(16) Wet (17) oppressed. (18) dew point.
(19) 35, 33°*C*.

III. Wrong statements are : (1), (2), (3) and (7).
(1) Frost is formed by the freezing of water in the atmosphere.
(2) Hail-stones are formed when the raindrops freeze.
(3) Dew is readily formed when R H. of air is high.
(7) its pressure remains unchanged (because saturated vapours do not obey Boyle's Law).

IV. (1) *c* (2) *b*, *d* (3) *b*, *d* (4) *b*, *d* (5) *a*

CHAPTER XX

I. (1) without (2) with (3) affected. (4) without
(5) not required. (6) slow ; fast (7) velocity of light.
(8) any—curved or straight ; straight (9) radiation.
(10) convection and radiation. (11) radiation.
(12) conduction, convection and radiation. (13) light.
(14) bad (15) poor (16) poor (17) good
(18) poor (19) one. (20) good absorber
(21) poor absorber (22) reflection, reflection and inverse square.
(23) black body.

II. (1) radiation. (2) also radiates (3) will not burn.
(4) quickly (5) greater (6) warmer (7) can be
(8) warmer than (9) no part. (10) liquids. (11) solids.
(12) steady (13) diathermanous.
(14) athermanous. (15) darker (16) brighter
(17) white ; black (18) more (19) decreases
(20) protect (21) faster (22) faster
(23) top (24) *d* (25) *d* (26) *c* (27) away from

III. (1) Davy (2) Searle (3) Prevost
(4) Forbe (5) Ingen-Hauz (6) Draper
(7) Ritchie (8) Stefan (9) Newton

IV. (1) Metals are good conductors of heat.
(2, 5) Convection currents in water.
(3, 6, 7) Convection currents in air.
(4, 8, 9) Air is a poor conductor of heat.

CHAPTER XXI

I. (1) 4.2 (2) 778 (3) $4{\cdot}2\times10^7$ (4) $100\times4{\cdot}2$ joules
(5) $(100+536)\times4{\cdot}2$ joules (6) an engine.
(7) a heat engine. (8) decreased (9) decreased
(10) entire block just

II. (1) a form of energy. (2) external (3) internal
(4) greater than (5) two (6) flywheel
(7) explosion (8) compression (9) more than
(10) less than (11) condensing type ; non-condensing type
(12) high (13) low (14) more
(15) cheaper (16) *c* (17) *d*
(18) *a* (19) *b* (20) *a* (21) *b*

III. (1) Davy (2) Joule (3) Searle
(4) Mayer (5) James Watt (6) Otto

CHAPTER XXII

I. (1) molecular vibration. (2) st. lines ; energy ; 3×10^8
(3) non-luminous ; luminous
(4) light can pass and objects can be seen : light cannot pass.
(5) part of light can pass. (6) eclipse.
(7) umbra ; penumbra (8) v/u (9) round.
(10) intensity of illumination. (11) illuminating power.
(12) $(\text{distance})^2$ (13) Earth, Sun, Moon ; Moon, Sun
(14) annular. (15) 2 (16) 5
(17) $7\frac{1}{2}$ minutes. (18) 1 lumen (19) lumen.
(20) sperm : $\frac{1}{6}$ lb. ; $\frac{7}{8}$ inch ; 120 grains/hr.
(21) physical (22) distance.

II. (1) illuminated. (2) absolutely dark. (3) grease-spot
(4) narrow (5) 4π (6) 4
(7) photometer. (8) picture. (9) of any shape.
(10) no focussing (11) larger (12) never occur.
(13) longer (14) bend (15) possesses
(16) gravitational pull

CHAPTER XXIII

I. (1) all ; regular ; obeying the laws of reflection.
(2) (*a*) image, object ; (*b*) image, object ;
(*c*) virtual ; laterally inverted.
(3) same ; polished (4) infinite.
(5) twice ; plane mirror ; (*a*) sextant.
(*b*) Lamp and Scale Arrangement.
(6) Infinite (7) Kaleidoscope (8) Periscope
(9) $n=\frac{360}{\theta}-1$, when 180° is exactly divisible by $\angle\theta$; and

$n=\frac{360}{\theta}$, when 180° is not exactly divisible by $\angle\theta$ and leave fraction if any.
(10) Parallax. (11) farther (12) half
(13) Virtual ; diminished ; a convex mirror
(14) aperture. (15) relative aperture.
(16) converged ; diverged (17) half

(18) Virtual, erect and enlarged ; focus and pole
(19) lateral inversion (20) focus ; centre of curvature.
(21) focus. (22) concave (23) convex
(24) centre of curvature (25) 1.

II. (1) +ve. (2) Concave (3) 5
(4) infinite. (5) increases (6) +ve ; −ve.
(7) pole. (8) 30°. (9) of his own size.
(10) concave (11) *b* (12) 15
(13) plane (14) different (15) possible

III. (1), (2), (3), (4), (5), (6), (7)—all correct.

CHAPTER XXIV

I. (1) towards (2) away from
(3) $\frac{(A+D_m)/2}{A/2}$; $\frac{\text{vacuum}}{\text{medium}}$; $\frac{i}{r}$; $\frac{\text{real}}{\text{apparent}}$.
(4) incidence ; refraction ; denser ; rarer
(5) higher (6) towards ; $A+D$.
(7) the position of minimum deviation.
(8) Second Law of Refraction. (9) lateral displacement.
(10) irregular refraction (11) twice its critical angle.
(12) white ; red

II. (1) *d* (2) thickness. (3) Ref. index
(4) ${}_b\mu_c$ (5) critical angle. (6) glass to water.
(7) *a* (8) *d* (9) *A* (10) depends.
(11) towards (12) does not affect (13) equal
(14) equal (15) *a* (16) decrease.
(17) polar regions. (18) *c* (19) cannot
(20) near. (21) *b* (22) *b*

III. (1) Rectilinear Propagation of Light. (2) Refraction.
(3) Newton's Corpuscular Theory of Light.
(4) Newton's Theory of Fits.
(5) Total Internal Reflection. (6) Erecting Prism.
(7) Mirage. (8) Looming or Fata Morgana.
(9) Prism. (10) Principal Section.

CHAPTER XXV

I. (1) lentil seed. (2) Opitical centre (3) Focus (4) at infinity
(5) Principal points (6) $f^2=x_1.x_2$. (7) $\frac{v}{u}=\frac{f}{u-f}=\frac{v-f}{f}$

(8) $\frac{1}{f_1}+\frac{1}{f_2}+\frac{1}{f_3}+\ldots$; $P_1+P_2+P_3+\ldots$

(9) dioptres ; $\frac{1}{f}$; f (10) —ve ; +ve.

(11) real ; virtual (12) convex (13) virtual.

II. (1) F and lens. (2) equal (3) virtual

(4) real and magnified (5) displacement

(6) concave mirror and convex lens.

(7) concave mirror and convex lens (8) spherical

(9) chromatic

(10) spot or plano convex lens or combination of concave and convex lenses.

(11) convex ; concave ; plane glass. (12) —2

(13) +40 (14) *b*

III. (1) Lateral Inversion. (2) Aperture. (3) Lens.

(4) Principal Axis. (5) Conjugate Foci.

(6) Parallax. (7) Power.

CHAPTER XXVI

I. (1) distant ; small (2) smaller ; larger.

(3) larger ; smaller. (4) slide ; opaque

(5) erect ; inverted (6) simple

(7) $\frac{\text{......image}}{\text{.........object when held at the distance of distinct vision}}$

(8) towards (9) relative aperture.

(10) Stereoscope (11) 25 cm. (12) sum

(13) difference (14) greater

II. (1) contracts (2) expands (3) accommodation.

(4) ciliary muscles. (5) myopia. (6) *a*, *b*

(7) convex ; concave ; cylindrical (8) long ; short

(9) *a*, *b*, *c* (10) *a*, *b*, *c* (11) *a*, *b*, *c*

(12) *b* (13) slide. (14) increased

(15) *b* (16) non-selective (17) *c*

III. (1) Optical Instruments. (2) Microscopes.

(3) Telescopes. (4) Epidiascope. (5) Yellow Spot.

(6) Blind Spot. (7) Aqueous Humour.

(8) Persistence of Vision. (9) Astigmatism.

(10) Magnifying Power *or* Angular Magnification.

(11) Normal Eye. (12) Depth of Focus. (13) Binoculars.

(14) Periscope. (15) Sextant.

IV. All correct except (1), (4) and (13).

CHAPTER XXVII

I. (1) seven ; spectrum. (2) real ; virtual (3) pure
(4) in the position of minimum deviation (5) Red ; violet
(6) increase. (7) Spectrometer.
(8) Direct-vision Spectroscope.
(9) Atomic or Line ; Molecular or Band
(10) Helium ; dark ; Fraunhoffer ; Fraunhoffer ; 700
(11) same (12) greater
(13) Michelson ; Octagonal Mirror Method : 22 miles.
(14) face ; face ; 2 (15) transmits (16) ultra-violet.
(17) black ; white. (18) ultraviolet waves (19) complementary
(20) green ; red (21) reflected (22) yellow
(23) green

II. (1) Roamer (2) disperse (3) collimator
(4) continuous (5) line (6) bright
(7) line (8) Continuous (9) absorptive
(10) discontinuous (11) Refrangibility (12) infra-red
(13) Violet ; red (14) not dispersed (15) White
(16) Green (17) *d* (18) *a*, *e*
(19) *a*, *b* (20) *b* (21) *c*
(22) *b* (23) *a* (24) *a*
(25) *c* (26) *b*

III. All correct.

CHAPTER XXVIII

I. (1) wave (2) longitudinal ; transverse.
(3) Longitudinal (4) Transverse
(5) cannot ; a continuous material medium ; each particle
(6) directly (7) λ ; *t* ; *t*
(8) (*a*) $\frac{\text{displacement}}{\text{acceleration}}$; (*b*) displacement ; (*c*) Sine
(9) vibratory body
(10) solids, liquids and gases ; solids and liquids
(11) longitudinal ; transverse
(12) Compressions and rarefactions ; crests and troughs.
(13) isothermal ; adiabatic (14) 0·61 (15) sound ranging.

II (1) longitudinal (2) velocity (3) quite different from

(4) wavelength. (5) faster ; faster (6) solids.
(7) *d* (8) *a* (9) *c* (10) independent of
(11) increases ; grater (12) better
(13) does not change (14) hydrogen ; oxygen.
(15) more (16) 20 to 20000 (17) 1/10
(18) same (19) poor

III. (1) to (7), and (9) and (10)—are correct.
(8) *wrong* (∵ Laplace modified Newton's formula).

CHAPTER XXIX

I. (1) Intensity, pitch, quality
(2) amplitude, distance and size of the source of sound, density of the medium and presence of resounding bodies.
(3) frequency (4) no. of harmonics present in the note.
(5) pitch. (6) a musical sound ; noise
(7) low pitch ; high pitch. (8) decreases ; increases
(9) increase (10) twice ; higher multiples.
(11) more (12) loudness, faintness ; difference ; number
(13) ten.

II. (1) *c* (2) *a*, *b*, *c* (3) in concord ; in discord.
(4) harmony ; melody (5) discord (6) *a*
(7) Edison. (8) *a* (9) slanting ; opposite
(10) louder (11) raises (12) same as well as different
(13) interval.

III. Musical sounds : (3), (4), (7).
Noises : (1), (2), (5), (6), (8).

CHAPTER XXX

I. (1), free ; forced (2) Reflection (3) without ; with
(4) 17 m ; 34 m. (5) more readily (6) Resonance
(7) longitudinally. (8) five. (9) higher.
(10) $V/2l$. (11) $V/4l$. (12) even numbered.
(13) odd numbered

II. (1) and (4) to (11)—are correct.

III. (1) *d* (2) *c* (3) *a* (4) *g*
(5) *f* (6) *b* (7) *e* (8) *h*

CHAPTER XXXI

I. (1) transverse. (2) fundamental tone.
(3) maximum ; zero (4) minimum ; maximum
(5) antinode. (6) nodes ; antinodes. (7) decreases.

(8) increases (9) increase
(10) laws of vibrating strings ; stationary waves.
(11) motion (12) fixed
(13) mean ; maximum (14) at the same time
(15) λ/4 ; λ/2. (16) stretched strings. (17) tension.
(18) thinner (19) phonograph

II. (1) *wrong*. (Fundamental tone is produced when a stretched wire is plucked from its centre).
(2) to (6) and 8 - all correct.
(7) *wrong*. (Pitch or frequency does not depend upon amplitude)

III. (1) Hydrophone. (2) Tuning Fork.
(3) Resonance Apparatus. (4) Kundt's Tube.
(5) Quincke's Tube. (6) Sonometer.
(7) Melde's Apparatus. (8) Phonograph. (9) Gramophone.

CHAPTER XXXII

I. (1) Lode stone ; an artificial (2) Magnesia
(3) directive (4) attract ; repel (5) surer test
(6) precedes (7) induction. (8) opposite ; same
(9) magnetic axis ; magnetic meridian.
(10) temporary ; soft iron. (11) permanent
(12) complete magnet (13) directive ; attractive

II. (1) equal (2) zero. (3) cannot
(4) ferro-; para-; dia-magnetic
(5) contract ; expand (6) neither attracted nor repelled
(7) steel : soft iron (8) separate (9) cling together

III. (1) *wrong*, [$\because$ mag. length$=\frac{7}{8}\times$(geom. length)].
(2) *wrong*. (towards North and South).
(4) *wrong*. (from North pole to South pole).
(3), and (5) to (8) —all correct.

IV. (*i*) Magnetic substances are : steel, nickel, iron and manganese.
(*ii*) The rest are non-magnetic substances.

CHAPTER XXXIII

I. (1) directly ; inversely (2) unit north pole (3) gauss ; oersted.
(4) 1 cm. ; another equal and similar ; 1 dyne.
(5) SN (6) NS (7) magnetic field.

II. (1) Coulomb. (2) Oersted
(3) Magnetic line of force ; direction (4) decreases
(5) remains same (6) $2M/\pi$ (7) vector ; vector (8) uniform

(9) weber. (10) 4 times (11) $\frac{1}{8}$th
(12) 8 times (13) equatorial (14) axial
(15) attracts

III. (1) *correct.*
(2) *correct.* (Third pole at the centre is called a consequent pole)
(3) *correct.* (On account of induction).
(4) *wrong.* (Parallel lines of force represent a uniform field).
(5) *wrong.* (Magnetic moment increases with the length of the magnet).
(6) *correct.*

CHAPTER XXXIV

I. (1) east-west ; parallel (2) north-south ; perpendicular
(3) aluminium (4) unspun silk
(5) sum and difference

II. (1) *e* (2) Null (3) Tan-*A* (4) east-west.
(5) aluminium pointer (6) mag. needle. (7) $\frac{1}{2}$
(8) $\frac{1}{4}$th (9) $\frac{1}{16}$th (10) $\frac{1}{2}$ (11) allowed.
(12) large. (13) zero. (14) slower

III. (1) *e* (2) *d* (3) *h* (4) *a* (5) *c*
(6) *b* (7) *j* (8) *f* (9) *g*

IV. (1) *wrong.* ($\because$ field strength is inversely proportional to the square of the distance).
(2) to (6) —all correct.

CHAPTER XXXV

I. (1) south. (2) mag. elements (3) dip, declination and *H*.
(4) geographical meridian and magnetic meridian.
(5) resultant mag. intensity (*R*) ; horizontal component (*H*).
(6) north pole (7) magnetic (8) aclinic
(9) isoclinic ; isogonic ; isodynamic (10) agonic

II. (1) 16 (2) mag. map (3) Mag. storm
(4) 90° (5) vertical (6) horizontal
(7) mag. equator (8) *d*

III. (2), (4) and (7) —correct.
(1) *wrong* ($\because H=R. \cos \phi$).
(3) *wrong* ($\because$ isogonic line is for the same declination *or* isoclinic line is for the same dip).
(5) *wrong* ($\because$ a mariner's compass always remains horizontal due to gimbals).
(6) *wrong* (It should be a stronger magnet).

CHAPTER XXXVI

I. (1) here we deal with static or standing electricity.
(2) charges ; equal ; opposite (3) Repulsion
(4) —ve. (5) movement
(6) +ve ; cat skin. (7) Conductors ; insulators
(8) Induction (9) loss ; gain (10) Franklin

II. (1) Induction (2) induced ; inducing charge
(3) same ; opposite (4) inducing (5) Charge ; outer
(6) friction and induction.

III. (1) *wrong* (∵ charge resides only on the outer surface).
(7) *wrong* (∵ g is measured by a simple pendulum).
(2) to (6), and (8) to (12) —are correct.

IV. (*i*) *Conductors* : water, human body, copper, gold, solution of common salt, mercury, carbon.
(*ii*) The rest are insulators.

CHAPTER XXXVII

I. (1) Coulomb ; his Torsion Balance.
(2) attraction ; repulsion ; directly ; product ; inversely ; square of the distance
(3) dielectric constant ; one. (4) +ve ; —ve
(5) contract ; expand (6) field intensity (7) $q.E$.
(8) 1/300 ; 3 (9) $6{\cdot}24 \times 10^{18}$
(10) potential ; level ; pressure (11) higher ; lower

II. (1) scalar ; vector (2) potential (3) zero
(4) uniform. (5) 1 cm. ; 1 dyne. (9) charge density.
(7) potential (8) never (9) *c* (10) *b*

III. All correct.

CHAPTER XXXVIII

I. (1) Charge/Potential (2) radius (3) $KA/4\pi t$
(4) $K[R.r/(R-r)]$ (5) parallel-plate (6) $9 \times 10^{11}; 10^{-6}; 10^{-1}$
(7) increases (8) solid dielectric. (9) loss
(10) Farad

II. (1) to (5), and (9) —all correct.

III. (1) *g* (2) *f* (3) *a* (4) *h* (5) *d* (6) *c* (7) *b* (8) *e*

CHAPTER XXXIX

I. (1) Benjamin Franklin (2) induction. (3) elec. energy.
(4) lightning. (5) induction ; conduction.

(6) Reverbrations or multiple echoes (7) leaks
(8) protect (9) high (10) Leyden jars

II. (1) electrons. (2) rises (3) induced
(4) lost. (5) opposite (6) cannot
(7) Van de Graaff's generator. (8) with

III. (1) *wrong* (∵ we should stand away from the tree lest it may be used as a lightning conductor).
(2) to (8) —all correct.

CHAPTER XL

I. (1) an intermittent ; a constant (2) MnO_2
(3) $CuSO_4$ solution. (4) NH_4Cl solution ; dil. H_2SO_4.
(5) cells. (6) highest ; lowest
(7) electrical ; chemical ; chemical ; electrical
(8) 2·2 volts ; 1·8 volts (9) parallel ; series
(10) Cu ; Zn ; dil. H_2SO_4.

II. (1) Chemical energy (2) Leclanche ; Daniell
(4) low (4) Leclanche ; wet.
(5) 1·5 ; 1·1 ; 1·08 ; 2·2 ; 1·90 (6) greater
(7) Smee's (8) electrodes. (9) b

III. (1), (2), (3), (6), (7) and (8)—are correct.
(4) wrong (∵ it contains wet paste of NH_4Cl electrolyte).
(5) wrong (∵ a strong current is produced by a dynamo).

IV. (1), (2), (3), (4), (5), (6) and (10) —Primary cells.
(7) and (9) — Secondary cells.
(8) Standard cell.

CHAPTER XLI

I. (1) Oersted. (2) circular
(3) current ∝ tangent of the angle of deflection.
(4) $\frac{H.r}{2\pi n}$ (5) in the magnetic meridian
(6) No setting (7) Moving Magnet Galvanometer.
(8) 10 (9) high ; low
(10) parallel ; series (11) increased (12) attract
(13) Roget. (14) Barlow's wheel.

II. (1) low ; parallel (2) high ; series (3) perpendicular
(4) south (5) perpendicular
(6) field ; current ; motion of the conductor.
(7) d (8) a (9) a (10) a (11) b (12) c (13) d (14) a

III. (1) to (10)—all correct.

CHAPTER XLII

I. (1) 1 ampere. (2) Specific resistance
(3) Ohm ; ohm × cm. ; mho (4) rheostat
(5) open circuit. (6) series. (7) decreases
(8) increases (9) potentiometer
(10) ratio arms (11) more

II. (1) opposes or decreases (2) zero ; infinite
(3) *d* (4) less (5) decreases (6) decreases
(7) closed (8) *d* (9) *d* (10) *b*
(11) *b* (12) *c* (13) thin. (14) increase
(15) decrease (16) increases (17) *c*
(18) ohm × cm (19) decreases ; increases
(20) *b* (21) greater (22) increased (23) increase
(24) *c*, *e* (25) infinite. (26) less (27) 1
(28) $\frac{1}{100}$ (29) *a* (30) P.O. Box (31) *c* (32) *c*
(33) *c* (34) *c* (35) less (36) *c*

III. (2), (3), (6) to (11), (15) to (17) and (19)—are correct.
(1) *wrong* (∵ current is due to the flow of electrons only)
(4) *wrong* (∵ 1 ohm $= 10^9$ e.m.u. of resistance).
(5) *wrong* (∵ 1 ohm $= 9 \times 10^{11}$ e.s.u. of resistance).
(12) *wrong* (∵ resistance will be high for a thin wire).
(13) *wrong* (∵ sp. resistance will be same for a thin as well as for a thick wire).
(14) *wrong* (∵ sp. resistance will be same as it does not depend upon the length of wire).
(18) *wrong* (∵ E.M.F. of a cell remains constant).

IV. (1) *c* (2) *d* (3) *f* (4) *e* (5) *a* (6) *b*

CHAPTER XLIII

I. (1) square ; resistance ; time (2) Tungsten ; carbon filament.
(3) better (4) Amperes × Volts. (5) greater
(6) more (7) low ; an alloy of tin and lead.
(8) Three (9) Constantan or manganin ; nichrome
(10) thermopile. (11) combination ; thermocouples.
(12) more ; increases. (13) thermocouple

II. (1) *Q.V* (2) two
(3) converting heat energy into electrical energy.
(4) parallel ; parallel (5) measuring radiant energy.
(6) 12 (7) *b* (8) Thomas Edison ; Seebeck

(9) increases (10) 25 (11) *b* (12) *a*
(13) *d* (14) *d* (15) *c* (16) *c* (17) parallel ; series.
(18) dangerous (19) *a* (20) *b* (21) *b*
(22) Inert (23) less

CHAPTER XLIV

I. (1) Electrolysis ; direct [D.C.]
(2) anode ; cathode (3) Anions ; —vely
(4) Cations ; +vely (5) metal ions ; non-metal
(6) electro-chemical equivalent. (7) 0·00001036 gm./coulomb.
(8) E.C.E. of H_2
(9) dil. H_2SO_4 of S.G.=1·215. (10) Carbon

II. (1) Electroplating as well as electrotyping
(2) metals (3) metals. (4) cathode (5) Faraday.
(6) platinum (7) carbon. (8) *d* (9) cations.
(10) cations. (11) anions. (12) anions. (13) —vely.
(14) +vely (15) 96470 (16) gm./amp./sec. (17) *a*, *c*, *d*
(18) *c* (19) ampere × hours.

III. (1) , (4) and (7) —are correct.
(2) *wrong* (∵ E.M.F. is measured by a potentiometer).
(3) *wrong* (∵ P.D. is measured by a voltmeter).
(5) *wrong* (∵ Carbon grains should be closely packed).
(6) *wrong* (∵ Both types of current can pass through electrolytes).

CHAPTER XLV

I. (1) production and duration ; strength ; direction
(2) attract ; repel (3) less (4) Unidirectional
(5) voltage ; amperage. (6) more (7) direct
(8) alternate (9) Alternate
(10) Slip or separate rings ; split rings (11) Armature
(12) armature. (13) telegraph (14) parallel

II. (1) Faraday. (2) Faraday's (3) Lenz's
(4) energy. (5) Right-hand ; Left-hand
(6) *c*, *d*, *e* (7) *b* (8) 22000 (9) Faraday.
(10) Ruhmkorff.
(11) Straight ; closed one (which includes circular and rectangular cores)
(12) *c* (13) *b* (14) *c* (15) *b* (16) *d*

(17) *c* (18) Graham Bell ; Morse (19) Two ; one
(20) *c* (21) *c* (22) unequidistant (23) *b, d, e*
(24) *a* (25) *c* (26) *a*

III. (1) to (3), (7) to (12), (14) to (17)—are correct.
(4) *wrong* (∵ Core of a transformer must be of soft iron).
(5) *wrong* (∵ We obtain a unidirectional current).
(6) *wrong* (∵ D.C. is passed in the primary coil of an Induction Coil while a transformer works with A.C. only)
(13) *wrong* (∵ Commutator converts A.C. into D.C.).

CHAPTER XLVI

I. (1) 30000 (2) 9000
(3) 100 cm. ; 5 cm. (4) Dark discharge
(5) +ve column. (6) Faraday's Dark Space
(7) Crooke's Dark Space (8) 10^{-3} to 10^{-4} mm. of Hg.
(9) green (10) mercury vapours.
(11) fast moving electrons ; 10^9 to 10^{10} cm./sec.
(12) deflected : as well as (13) cathode rays ; high
(14) as waves ; no ; light (15) living cells.
(16) α, β and γ rays (17) +vely ; −vely ; not
(18) electro-magnetic radiations ; fast moving electrons ; Helium nuclei.
(19) alpha rays. (20) neutrino.
(21) Protons ; neutrons ; electrons.
(22) 2, 6, 18, 32,... (23) Isotopes
(24) Isobars or Isomers (25) nuclear fission
(26) Radioactivity (27) produce
(28) Radioactive (29) neutron
(30) neutron. (31) Atom bomb
(32) Atomic reactor (33) Breeder reactor

II. (1) positive or canal (2) cathode
(3) st. lines (4) D.C. (5) *b, c*
(6) D.C. (7) wave form (8) equal to
(9) *d* (10) obey (11) *a* (12) *d*
(13) *b* (14) *a* (15) *c*
(16) invisible (17) decreases (18) *d* (19) more
(20) liberate (21) less ; more ; not at all

(22) *b* (23) *a* (24) *c* (25) *d* (26) *c* (27) *d*
(28) *d* (29) *a* (30) *a* (31) *d* (32) *c* (33) *b*
(34) *a*, *d* (35) *e* (36) *b* (37) *d* (38) *c* (39) *c*
(40) *d* (41) *d* (42) *a* (43) *d*, *g* (44) *a*, *b* (45) *b*
(46) *a*, *b* (47) *d* (48) *b* (49) *c* (50) *a*
(51) *a*, *b*, *c*, *f*, *g*, *h*, *i* (52) *a*, *d*, *e* (53) *b*, *d*, *e*
(54) gamma rays (55) Electrons ; plate (56) *a*, *c*, *d*

III. (7), (13), (20), (21) and (23)—are wrong.
The rest are correct.

IV. (1) *f* (2) *d* (3) *b* (4) *a* (5) *c*
(6) *e* (7) *g* (8) *j* (9) *k* (10) *m*
(11) *n* (12) *h* (13) *l*

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